WATER RESOURCES MANAGEMENT PLAN

SALINAS PUEBLO MISSIONS NATIONAL MONUMENT

Prepared by

National Park Service
Salinas Pueblo Missions National Monument
Mountainair, New Mexico

and

Natural Resource Program
Southwest Support Office
Santa Fe, New Mexico

in cooperation with

National Park Service
Water Resources Division
Fort Collins, Colorado

Approved by: 4.1.97

Superintendent, Salinas Pueblo Missions National Monument — Date

1997

metric conversions

Multiply this Unit	by	To Obtain
acres	0.405	hectares (ha)
inches	2.54	centimeters (cm)
inches	25.4	millimeters (mm)
meters	3.28	feet
miles	1.61	kilometers
cubic feet	0.028	cubic meters
cubic meters	35.3	cubic feet
square miles	2.59	square kilometers
square kilometers	1000	hectares
acre-feet	1233	cubic meters
cubic meters per second	35.3	cubic feet per second
cubic feet per second	0.028	cubic meters per second

CONTENTS

APPENDICES

LIST OF FIGURES

EXECUTIVE SUMMARY

Salinas Pueblo Missions National Monument consists of three non-contiguous resource units with their headquarters located in Mountainair, New Mexico. This Water Resources Management Plan provides an overview of the watersheds and water resources at these three units, interprets available water resource information, notes some key sources of expertise, identifies water resource concerns and lists some data and information needs. A summary of technical recommendations and four specific "Project Statements" (proposals for projects) are then provided.

The main focus of the report is on the 295 acre Abó Unit and the 99.6 acre Quarai Unit, which lie in the foothills of the Manzano Mountains and are the two sites where permanent surface waters occur. The third unit, Gran Quivira, comprises 611 acres on a hilltop and contains no streams or springs.

Precipitation at the Salinas Headquarters averages 14.8 inches per year, much of it occurring during the summer thunderstorm period. No major streams occur in this part of New Mexico, and most streams or arroyos flow only after downpours during the summer storm season or during snowmelt periods.

Springs are scattered in the Manzano Mountains and foothills above the Quarai and Abó Units, but most of these springs are intermittent. However, both of these units have permanent springs within their boundaries. Ground water in the area typically is hard and in cases wells are high in sulfur; whereas, spring waters tend to be from more shallow aquifers and generally not as mineralized.

No actual surface hydrologic data exist for the Abó and Quarai Units, and specific information on stream aquatic biology likewise is lacking. Some information does exist on ground-water levels in the area. This report extrapolates from existing information in the area to provide a general characterization of water and sediment yields for the two units. A Project Statement focuses on the need for hydrologic information.

The largest arroyo cutting through the Abó Unit is the main stem of the 20.1 square mile Cañon Espinoso watershed, with the highest extremity of this arroyo 11.8 miles upstream. This arroyo (or stream) exhibits a permanent, but often small discharge. At places the Cañon Espinoso's flow goes under ground --a pattern typical for arroyos in the area, according to geologists.

Stoney, shallow soils in the upper Cañon Espinoso watershed convert a high percentage of storm rainfall into surface runoff, producing high storm discharges in the main arroyo of the Abó Unit.

The Corps of Engineers predicted the theoretical storm surface runoff at the bottom edge of the Quarai Unit at 77 cubic feet per second for a 2-year event and 1,480 cfs for a 100-year event.

Flood risks at the Abó or Quarai Units do not appear extreme according to flood plain delineations by the Corps of Engineers, since their floodplain maps show the ruins and other buildings above the 100-year flood line.

The Sisneros Family spring, in the inholding of the Abó Unit, has met domestic and garden irrigation needs dependably over the centuries, even during droughts. The geologic formations below the Abó Unit also offer a good potential for deeper well development at the Unit --something which is recommended in one of the Project Statements.

It is <u>estimated</u> that the main arroyo at Abó yields about 1070 acre feet of water annually in surface flow, or an average flow of about 1.5 cubic feet per second.

The 20.1 square mile Cañon Espinoso watershed, in which the Abó Unit lies, <u>theoretically</u> yields about 13 acre feet of sediment annually, i.e., the sediment passing through the Abó unit in an "average year" based on erosion and sediment yield estimations.

The main arroyo in the Abó Unit is mostly cut down to bedrock, providing stability of the channel. Some sheet and gully erosion is active in the northwestern part of the Abó Unit, which is in an area where arroyos originate about 4 miles upstream and can produce strong flows. Earlier, grazing may have caused erosion in the Unit, but cattle were removed about three years ago, and vegetation therefore is making a comeback.

Salt cedar (*Tamarisk pentandra*) has been invading some stream areas throughout the Cañon Espinoso watershed and within the Abó Unit, and the park continues to fight these exotic plants by cutting and focused herbicide use.

Information is needed on the aquatic biology for both the Abó and Quarai Units, especially for the latter, and one of the four Project Statements aims at this topic.

The springs of the Quarai Unit produce a small but dependable flow that supports an <u>estimated</u> 5 acres of critical riparian or wetland vegetation within the Unit as well as another estimated 2 acres on private land downstream from the Unit's boundary. These wetlands serve as critical habitat for birds and wildlife.

The Quarai springs together yield an <u>estimated</u> 45 acre feet of water annually or averaging about 0.06 cubic feet per second or 28 gallons per minute. The springs' water is pH-neutral, of modest hardness, with low metals and good clarity. A safe drinking water for the Unit comes from a 90-foot deep, drilled well located just north of the visitor center.
The main arroyo in the Quarai Unit forms a ravine about 500 feet long, at places over 20 feet deep. Except for some minor bank sloughing at spots, the ravine is stable and contains old trees and a well-established vegetation.

An old acequia (irrigation ditch) operated at the Quarai Unit until 1972, with its intake point about 100 feet above the present downstream boundary of the Unit. Some local villagers would like to rehabilitate this acequia; however, the water rights issues for this ancient water use are at best complex and clearly in need of legal analysis (and the topic of a Project Statement in this report). Rehabilitation of the acequia potentially could affect the wetlands in the area, raising the issue of wetland protection.

The Gran Quivira Unit receives as much precipitation as the other two units, but contains no surface waters. The land surface around this Unit is characterized by scattered, "karst" sink holes. What summer precipitation is not lost to the high evapotranspiration of the area becomes ground-water recharge and percolates down into sink holes, crevices and solution channels. Soils are subject to erosion from the dry winds and from occasional pounding by thunderstorms, so small rills and gullies appear throughout the unit --although many of these cuts appear to be down to harder rock. The unit has a deep well which supplies a dependable and safe, although mineralized, water.

INTRODUCTION

1- INTRODUCTION

Salinas Pueblo Missions National Monument consists of three noncontiguous resource units --Aber, Quarai and Gran Quivira -- with a headquarters at Mountainair, New Mexico. The monument was established to preserve ruins of prehistoric Indian pueblos and associated Spanish Franciscan mission ruins from the Seventeenth Century. The prehistory of the area extends back for more than 10,000 years (Salinas National Monument, 1984). The name Salinas relates to the monument's location in what was known in Spanish Colonial times as the Salinas Jurisdiction, because of the salt lakes (salinas) found in the area. Salt played an important role in the early settlement and trade of the region.

The monument headquarters are located in the small town of Mountainair, NM, about 85 highway miles south of Santa Fe in the Estancia Basin. The monument's three resource units lie within a 15 to 25 minute drive from the headquarters. Most of the Estancia Basin lies in Torrance County. The town of Estancia —the county seat— is located in the central, mainly agricultural, part of the basin known as the Estancia Valley (Figure 1).

2- PURPOSE OF THE.REPORT

Water is a significant resource in many units of the National Park System and a particularly important facet of management in all units of the arid parts of the West. Water access, droughts, erosion and conflicts over water have always shaped history in arid zones; therefore, an understanding of water resources is essential for interpreting cultural and historic features in national monuments in the Southwest.

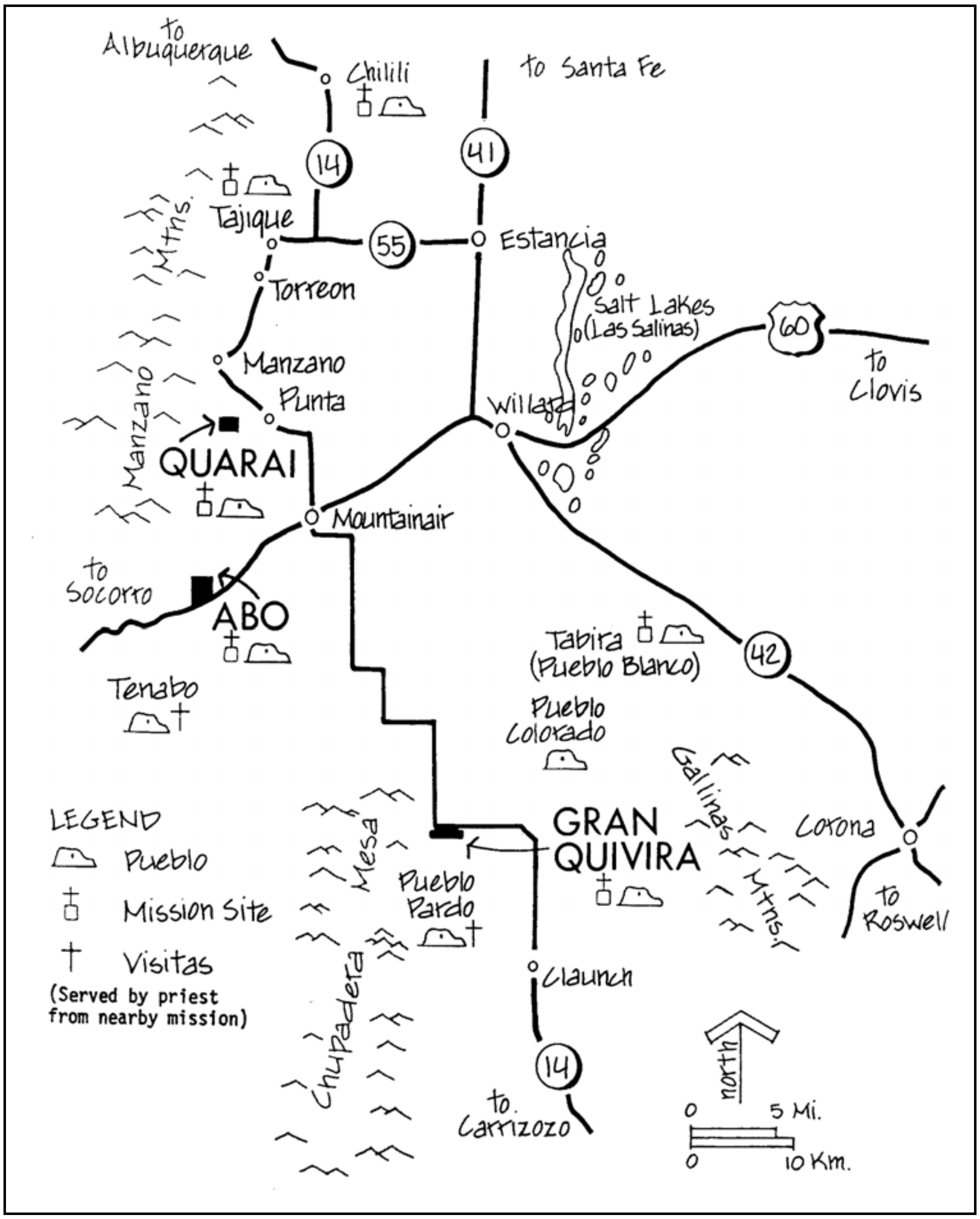
Water resources of course also play a key role in a park's overall operation, for assuring an adequate water supply, managing waste disposal and in terms of aquatic ecosystems. Water rights issues also tend to be a preoccupation in arid areas. A knowledge of water resources therefore is one of the tools for planning and operating a park unit.

This report provides an overview of the watersheds and water resources at the Salinas Pueblo Missions National Monument's three units, interprets available information on the watersheds, identifies some water-resource related issues, points out certain data and management needs and provides recommendations about addressing the concerns identified.

A list of information sources and experts also is included in Appendix B, to provide the park with contact points for followup on the water resource issues raised.

Figure 1 The Estancia Basin area, showing the Salinas Pueblo Missions National Monument and location of its Abó, Quarai and Gran Quivira Units. The Park Superintendent's Office is in the town of Mountainair. A major geographic feature is the Manzano Mountains, which rise to about 10,000 feet west of the Abó and Quarai Units.

(Map from General Management Plan, Salinas NM, National Park Service, 1984)



GEOGRAPHY OF THE ESTANCIA AND SALINAS AREA

1. PHYSICAL LOCATION OF THE UNITS

The Manzano Mountains, which form the western rim of the Estancia Basin, are the prominent feature of this part of the state. The Manzanos rise to 10,000 feet in elevation, in contrast to the flat Estancia Valley to the east with its 6,000 to 7,000 feet elevations. Two of the park's units, the Abo and Quarai, are located in the foothills of the Manzanos and each is only about 10 air miles from 10,097 foot Manzano Peak (Figure 1).

All three units of the National Monument lie in or on the edge of the Estancia Basin, and the headquarters in Mountainair and the Quarai Unit are both hydrologically inside the basin. The Abdo Unit sits in the southwest edge of the Estancia Basin, but its stream turns west and empties into the Rio Grande drainage. The Gran Quivira unit is perched on the escarpment of Chupadera Mesa, at the southern edge of the Estancia Basin and at approximately the same elevation as the main valley floor, and runoff from Gran Quivira disappears into the ground in the northern fringe of the closed Tularosa Basin.

No major streams are found in the National Monument's units, so consequently no permanent stream gages or water monitoring facilities have been maintained by Federal or state agencies, and surface water data are lacking. More ground-water data are generally available, since farms in the valley use wells for irrigation and since the U.S. Geological Survey monitors a network of wells.

2- LAND USE

The western slopes of the Estancia Basin, above the Abo and Quarai Units, lie mainly in the Cibola National Forest. The National Forest yields some wood products, provides grazing areas and meets recreation demands for activities such as hiking, camping and hunting. National Forest policy also recognizes mountain watersheds as key water source areas.

In the Estancia Valley near the headquarters at Mountainair and around Gran Quivira dryland farming and ranching are the dominant land uses. The towns in the area are all small, and without significant industrial development. Albuquerque and Santa Fe's urban populations are only about an hour and a half drive away and provide some visitors to the area.

3- GENERAL GEOLOGY, SOILS AND VEGETATION

Several generations of Precambrian mountains formed in the area (Chronic, 1987), and the higher peaks of the Manzano Range, west of the Monument, include highly altered sedimentary and igneous rocks as well as relatively unaltered granite higher in the mountains (Figure 2). In the Estancia valley, where Mountainair is located and just east of Quarai, the land is covered with valley fill materials of sand, gravel, silt and clay, some up to 325 feet thick, derived from erosion of the Manzano Mountains during geologic uplifting.

In the foothills geologically younger sedimentary rocks overlie the Precambian rocks, the most evident being the red sandstone, siltstone and shale of the Abo and Yeso Formations at the Abo Unit. The Abo Formation ranges from 700 to 900 feet thick at different places around the Estancia Basin and the Yeso Formation from 600 to 1000 feet (White, 1994).

The Gran Quivira Unit sits on the Chupadera Mesa, which is capped by the lighter colored limestone member of the San Andres formation. This later formation lies above the medium or lighter red Yeso sandstone formation, which in turn lies above the dark red Abo Formation. The area generally is marked by some sinkholes and playas (Smith, 1957). The missions and pueblos were built from local rock, so Gran Quivira contains the lighter-colored San Andres limestone; whereas, dark red Aber sandstone provided the building materials at the Abo and Quarai units.

The soils for the Monument's units fall into four basic types, as shown in Figure 3. Quarai falls into the Witt-Wilcoxson-Turkeysprings association, which is predominantly loams on the less sloped areas and stony outcrops along the ridges. AbO sits on the La Fonda-Alicia-Rock outcrop association, mainly thin reddish loams with rock outcrops. Gran Quivira falls into the Otero-Palma-Trail association, which tend to be fine, light-brown sandy soils (Bourlier, *et al.,* 1970). Further details on soils appear in the following sections on the three specific units.

In the flatter areas at around 6,000 feet, the natural vegetation is mainly grasses, shrubs and some scattered junipers. At higher levels, the vegetation becomes mainly that of the P4non-Juniper Belt, with one-seed juniper *(Juniperus monosperman),* pinon *(Pinus monophylla)* and associated species. Still higher in the foothills of the mountains, at about 7,500 feet, the vegetation merges into Ponderosa pine *(Pinus ponderosa),* alligator juniper *(Juniperus deppeana)* and Gambel oak *(Quercus gambelii)* and other species of the Pine-Oak Belt. Finally toward the upper limits of the basin (above the park units) from about 8,000-10,000, species of the Fir-Aspen and Spruce-Fir Belts make up the cover (Elmore and Janish, 1976).

4- GENERAL HYDROLOGY AND CLIMATE.

No major streams occur in the area, and most streams or arroyos flow only after downpours during the summer storm season or during snowmelt periods. Rain in the Manzano Mountains and foothills ranges from 20-23 inches per year, with two-thirds of it occurring mostly in the April to September period. Most recharge to ground water in the mountains has to occur during the winter snowmelt or rain periods, when evapotranspiration is low.

From observing ground-water levels, some hydrologists suspect that the lag time between a change in mountain precipitation and a resultant fluctuation in ground-water level out in the valley is perhaps about 2 years (personal communication, State Engineer Office and Shomaker, 1996). There are many springs in the mountains and foothills, as seen at Quarai and near Abo, but most of these springs are intermittent (Smith, 1957).

Precipitation at Mountainair averaged 14.77 inches during the 30 years of 1965-94 record (Figures 4). Extremes occur, for example the 6.82 inches of scant precipitation total at Mountainair in 1934 was followed by the record year of 27.00 inches total in 1941 (New Mexico State Engineer Office, 1956). The relative humidity during daytimes is usually only 20-30 percent. Mountainair has 22 days a year with a maximum temperature over 90° F and 162 days a year with a minimum under 32° F, with a mean January temperature of 32.3° and mean July temperature of 70.8° (Garwood, 1996).

The average evaporation potential is over 50 inches per year, reflecting the low humidity and wind of the area (Smith, 1957 and White, 1994). The level of precipitation at Gran Quivira, at approximately the same elevation as Mountainair, is more similar to the Manzano foothills, or slightly higher (further data in the Gran Quivira section). As would be expected, rainfall is less in the valley than in the mountains above the Abo and Quarai Units.

In the north end of the main valley of the Estancia Basin, where ground water is pumped for irrigation and municipal use, the ground-water level has been declining at about a foot per year, according to wells monitored for several decades (Wilkins and Garcia, 1995), and use of water regularly exceeds recharge of water (White, 1994 and Shomaker, 1996). But in the southern and southwestern part of the basin, where the National Park Service units occur, ground-water levels generally do not show these declines (Wilkins and Garcia, 1995). In response to concern over increasing water withdrawals and export of water out of the basin, the Torrance County Commission has established a water resource planning work group, to assess the water resource status, trends and demands, and to establish a 40 year water development policy for the county and the Estancia underground water basin. A draft report by Shomaker and Associates (1996) is the first report of this group.

The National Monument's headquarters relies on the water of the town of Mountainair, which draws on wells drilled into the Yeso Formation. The town has a water right to store 1,565 acre feet of water for use as a public water supply (Shomaker, 1996). Water supplies for the other sites are discussed in their respective sections.

Note that water rights documentation for all National Park Service (NPS) units is collected by the

Water Resources Division of the NPS in Fort Collins, Colorado. The documentation available in these water rights dockets concerning Salinas Pueblo Missions NM as this report is prepared contains little information to adequately define NPS water rights at the park according to New Mexico State Law.

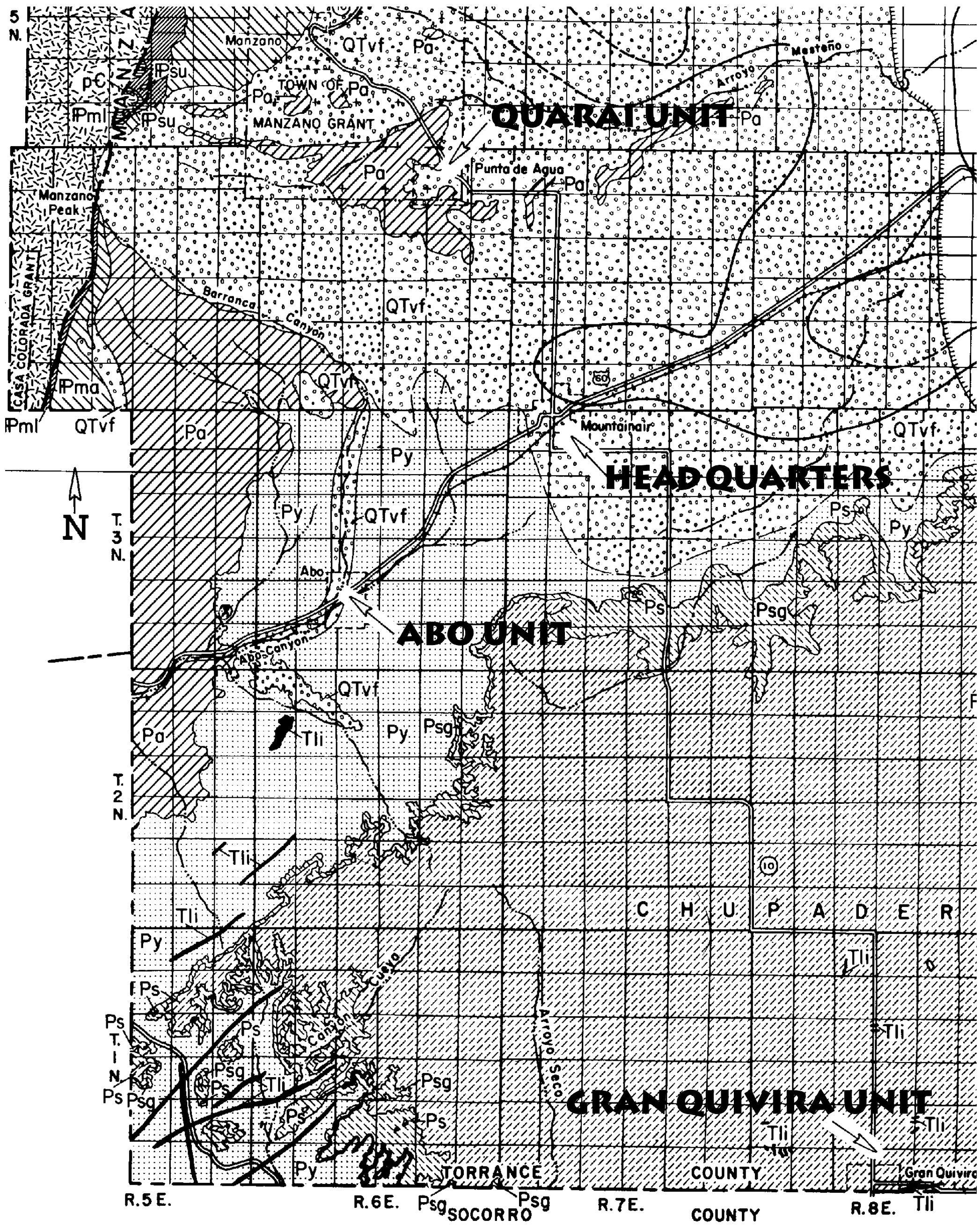


Figure 2. Overview of geology of the general Estancia Basin area, from Smith (1957), showing location of the three park units in relation to the principal geologic formations. Pa = Abó Formation; Py = Yeso Formation; QTvf = Valley fill; and Ps = Limestone member. Tli = Dikes and sills.

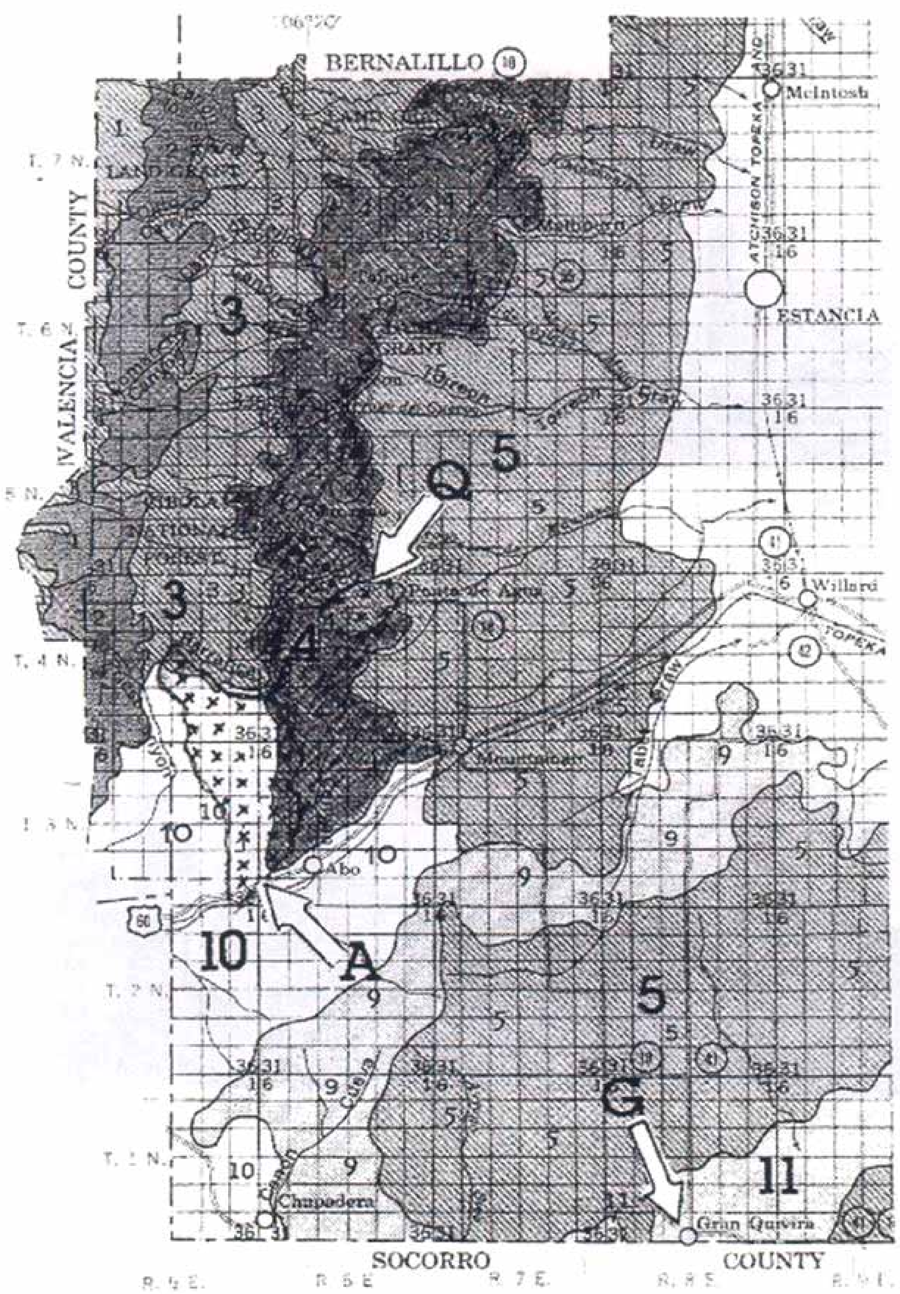
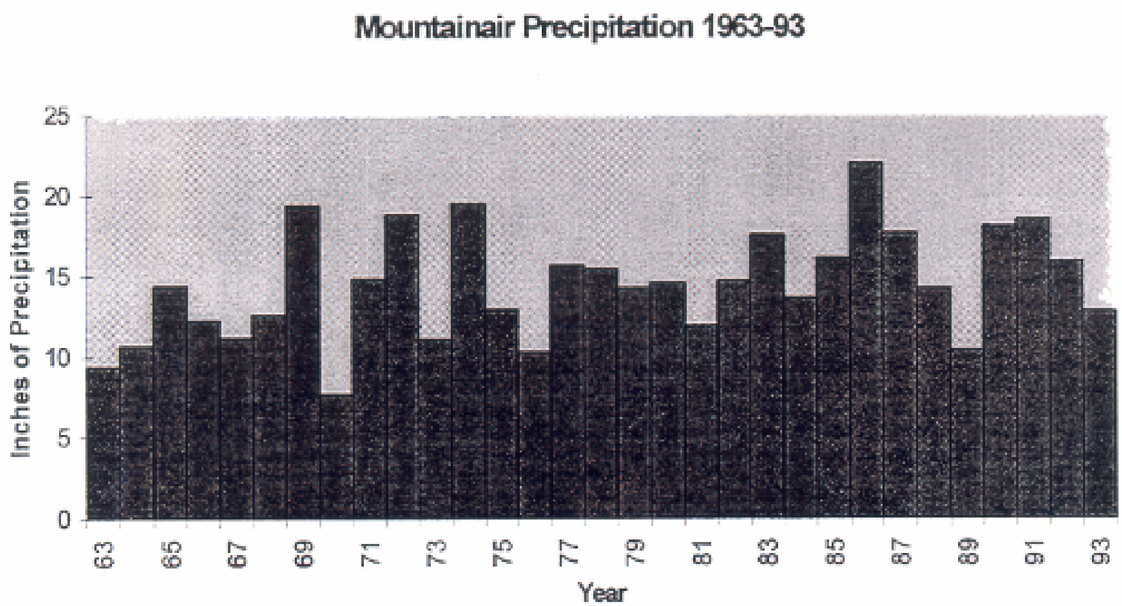


Figure 3. General soil map for the Estancia Basin are. The man soils group around the park units are: No 3= Wilcoxson-Supervisor Pin Association; No. 4= Witt-Wilcoxson-Turkeysprings Association; No. 5= witt-harvey-Manzano Association; No. 10= la Fonda-Alicia-Rock outcrop Association; No. 11=Otero-Palma-Trail association, as classified by the Soil Conservation Service, 1970 (Bourlier, et al., 1970). More soils detail appear in the three units' chapters in this report. The three arrows show "Q"= the Quarai Unit, "A" = the Abo Unit, and G= the Gran Quivira Unit; ant the areas hatched with x-marks define the watershed at the Abo and Quarai Units.



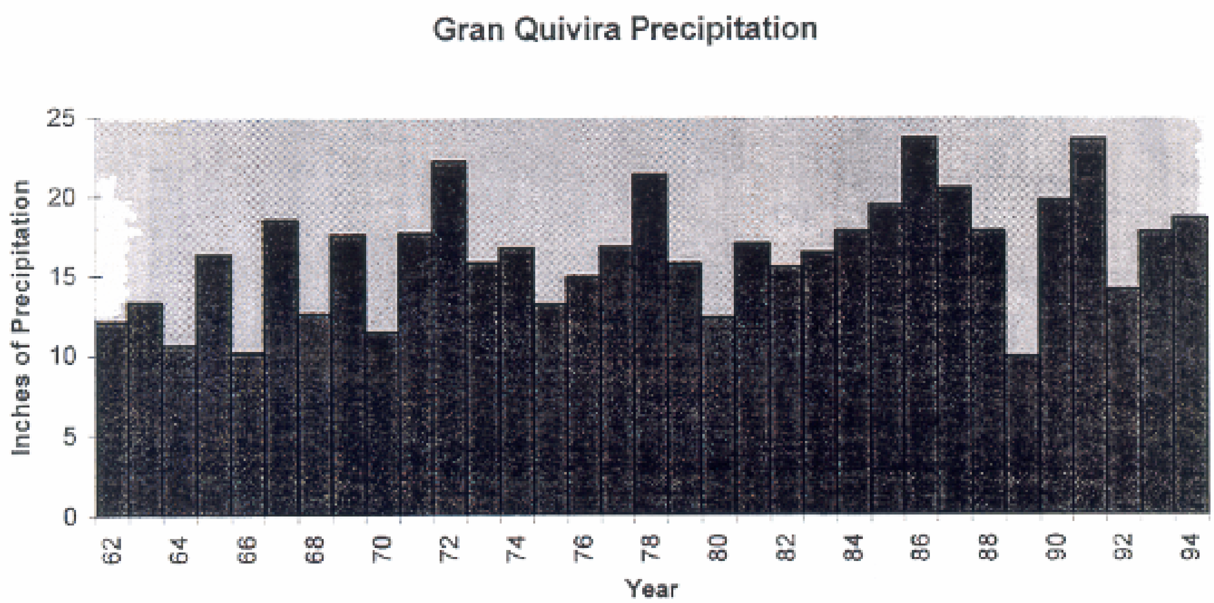


Figure 4. Precipitation at Mountainair during 1963-93 (top) and at Gran Quivira during 1962-94 (bottom).

THE ABO RESOURCE UNIT

1- CANON ESPINOSO WATERSHED OVERVIEW

The arroyo just east of the Visitor Center is the main channel of the 20.1 square mile Canon Espinoso watershed, an arroyo or stream whose flow originates in the Manzano Mountains. The National Park Service's 295 acre Abo Unit is squeezed into the lower extremity of this large, elongated watershed (Figure 5).

The main Canon Espinoso arroyo originates at 7,840 feet elevation, about two miles southeast of 10,098 ft Manzano Peak --the highest peak in the range— and drains foothills and mountains, mostly Cbola National Forest lands. The main channel of Canon Espinoso drains southeastward out of the National Forest for 11.8 miles, from the highest watershed divide to the watershed mouth, and loses almost 2,000 feet elevation en route. At the bottom end of the watershed, at about 6,000 feet elevation, the arroyo passes through the Abo Unit, then empties into the Abo Arroyo, at 5,935 feet elevation. Abo Arroyo is a major tributary of the Rio Grande and drains 226 square miles.

2- CLIMATE, GEOLOGY AND HYDROGEO LOGY

Specific climatic data or hydrologic data are not available for the AbO Unit or Canon Espinoso, although the overview of climate for Mountainair provided in the Introduction section lends a good indication. An estimate of the Canon Espinoso watershed's precipitation would be: about 14-17 inches annually for the 6-7,000 foot Pinon-Juniper Belt and perhaps 17-20 inches in the upper Pine-Oak Belt of above 7,000 to nearly 8,000 feet. This estimate is based on isohyet maps for the area, data from Mountainair (14.8 inches) and precipitation levels in Tajique (about 19 inches), and in view of vegetative indicators, recognizing that the Pine-Oak Belt vegetation "typically requires about 20 inches" (Elmore and Janish, 1976).

As described briefly under the General Geology section of the Introduction, the Abo Unit is located in the foothills where two kinds of sedimentary rocks occur, namely the Abo and Yeso Formations (Figure 2). These two layers overlie older Precambian rocks of the Manzano Mountains, with the Yeso deposited on top of the Abo Formation. (Smith, 1957; Bates, *et al* 1947). Chronic (1986) describes the ruins at Abo as sitting between the lighter red or gray Yeso Formation to the east and the dark red and brown sandstone and mudstone rocks of the Abo Formation to the west; however, Meyers (1982) describes the Abo ruins as more in the middle of the Abe) Formation, noting "excellent exposures of the Abo (Formation) may be seen in ... the vicinity of Abe) ruins." Field observations show both types of rocks are evident at the Abo Unit. The main channel is clearly set in the darker red Abo rock, and lighter red to gray Yeso Formation is evident just west of the ruins.

The Abe) Formation dips southeastward and is about 300 feet thick at the Abe) Unit (Chronic, 1987). As seen in Figure 2, the upper half of Canon Espinoso watershed lies on Abo Formation whereas the lower half is mainly in Yeso Formation (Smith, 1957; NRCS, 1996; Woida, 1996).

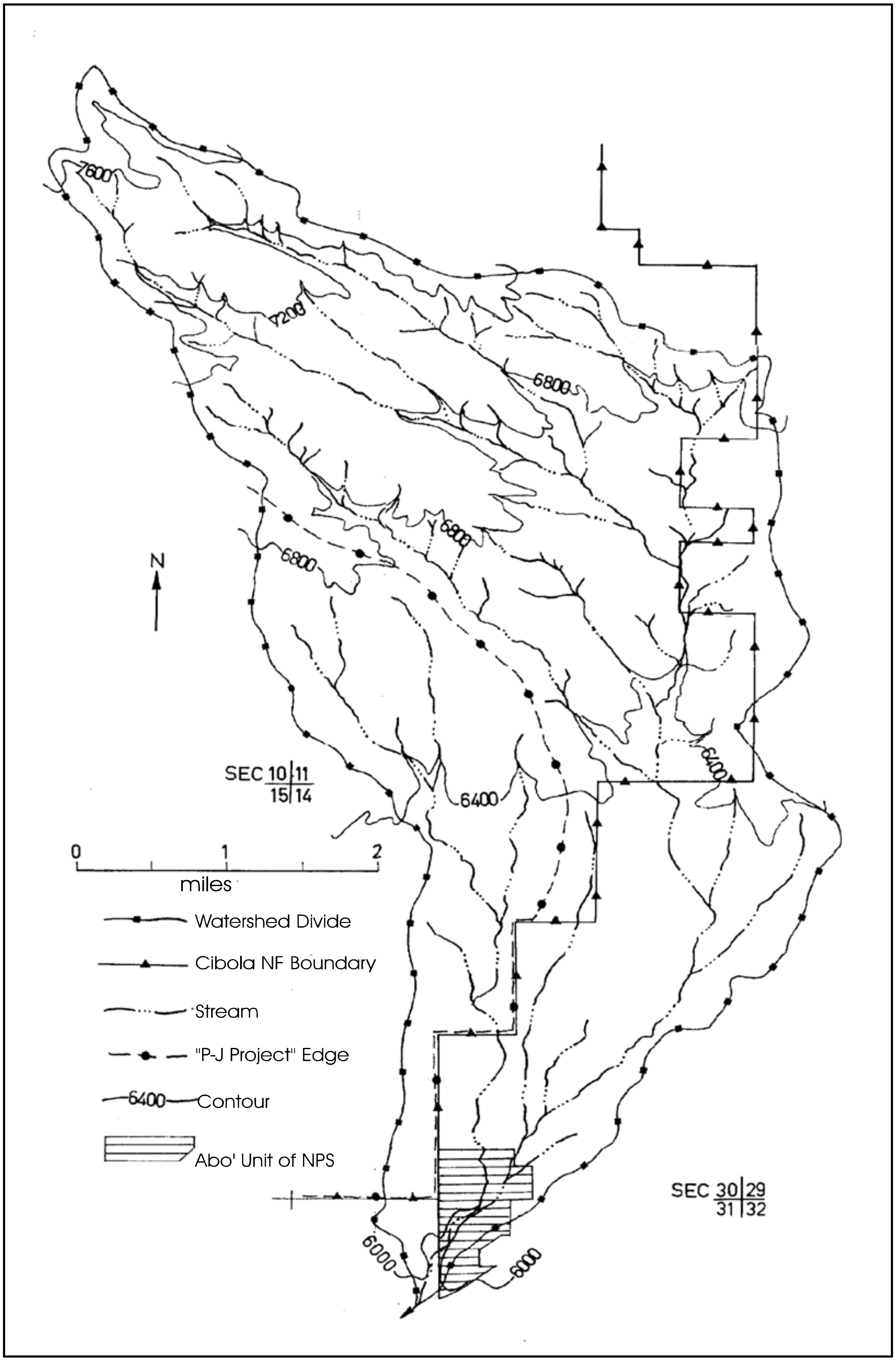


Figure 5. The Cañon Espinoso watershed, showing the watershed divide, Abó Unit's location, the boundary of the Cíbola National Forest, eastern edge of the "piñon-juniper project" and other features.

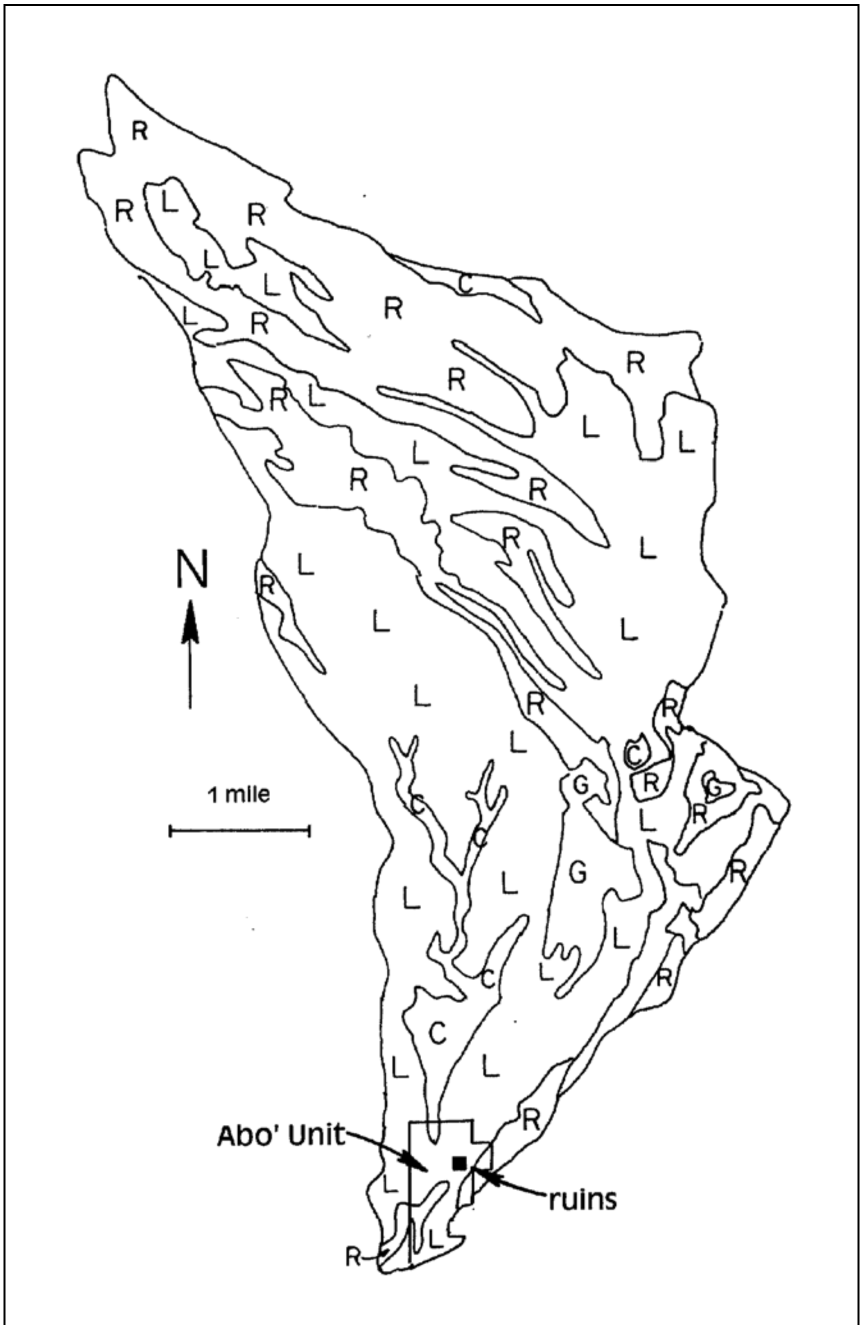
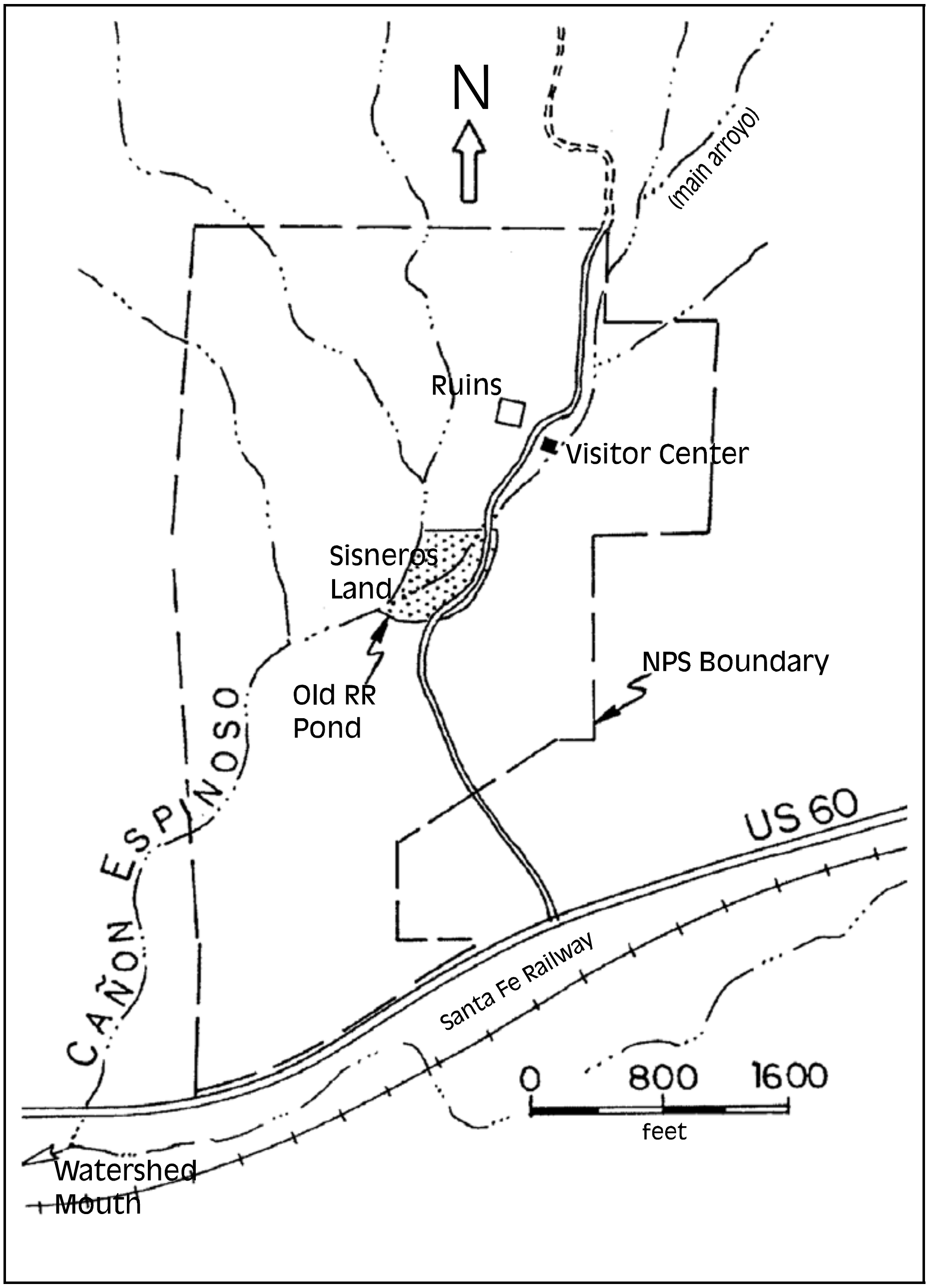


Figure 6. A generalized soils map of the Cañon Espinoso watershed, based on Soil Conservation Service maps (Bourlier, et al., 1970). R = a group of six rocky or cobbly soils; L = a group of six loams; C = Moriarty clay loam; and G = a group of four gravelly loams, as discussed in the text.

Figure 7. The Abó Unit and its arroyos. The main stream and arroyo, the Cañon Espinoso, which originates nearly 12 miles upstream, is seen coming into the <u>upper</u> <u>right</u> of the figure. This main stream then flows to the southwest, emptying into



the Abó Arroyo watershed (in the lower left corner of the figure). The arroyo coming in the <u>upper center</u> of the figure originates about four miles upstream, so also has strong storm runoff and sediment loads.

VEGETATION

In 1994 a vegetation survey was conducted inside the Abo Unit's 295 acre boundary (Floyd-Hanna et *al,* 1994). Their survey sorts the vegetation into five communities: 1. the riparian area (cottonwoods, bulrushes, willows, etc) along arroyos; 2. the common juniper-shrub-grass zone such as near the ruins; 3. upland areas where pinons are dominant; 4. some mainly grassed zones; and 5. some almost-riparian disturbed areas with chamisa (rabbitbrush), tamarisk and other disturbance indicators. The report also notes exotic plants.

In the entire Canon Espinoso watershed, lower elevations by the Abe, ruins are in the Pinon-Juniper Belt, with scattered junipers *(Juniperus monosperma)* and associated shrubs, forbs and grasses. Higher up the Canon Espinoso, pinons *(Pinus monophylla)* become larger and more common, and by the middle elevation levels of the watershed, at about 7,000 feet, Rocky Mountain junipers *(Juniperus scopulorum)* are abundant. The Pinon-Juniper Belt blends into the Pine-Oak Belt about halfway up the watershed, where Ponderosa pines *(Pinus ponderosa),* gambel oaks *(Quercus gambelii)* and wavyleaf oaks *(Quercus undulata)* prevail as the main indicator trees, along with some distinctive alligator junipers *(Juniperus deppeana)*. The upper extremes of the watershed, over 7,500 feet, comes close to the lower edge of the Fir-Aspen Belt, and a few representative trees such as Douglas fir *(Pseudotsuga menziesii),* can be spotted. Riparian zones along the arroyos exhibit cottonwoods *(Populus spp),* willows *(Salix spp),* cattails *(Typha spp)* and other wetland species, as well as some encroaching salt cedar *(Tamarix pentandra).*

3- SOILS, EROSION AND SEDIMENTATION

The Abe, Unit itself has not had a detailed soils survey; however, the general soils map for the Torrance Area by the Soil Conservation Service --now the Natural Resources Conservation Service--provided a basis to prepare the generalized map of Canon Espinoso watershed soils in Figure 6 (Bourlier et al, 1970).

The map in Figure 6, as well as field observations, show that a large part of the upper Canon Espinoso watershed is dominated by rock outcrops and stoney soils, especially on the steeper slopes along arroyos and ridges. The southern portion of the watershed, on the other hand, contains more loamy or clay-loamy soils, generally alkaline, including Alicia, Hassell, Encierro-Channery, La Fonda, Tapia, Witt and Pinon-Channery. Other soils include the clay loamy Moriarty, Jekley and Wilcoxson and the gravelly loams Washoe, Chilton and Scholle (Figure A-2). Specific characteristics of these soils and their distribution within the watershed appear in the Torrance Area soil survey book and its appended maps (Bourlier et al, 1970).

Erosion is occurring in various parts of the watershed, and sites are seen where soil fines have been washed away and the coarser stones and pebbles have been left behind on the surface as an "erosion pavement." Some slopes in the headwaters of the Espinoso Canon watershed tend to be dominated by this erosion pavement (field observations). Erosion has been active in arroyos in the northwestern part of the Abe) Unit. Some of the erosion is presumably natural, but past grazing and other land use effects in the watershed have no doubt contributed to these erosive conditions as well. As noted by Pawelek (1993) most gullies in this part of the country were probably initiated long ago, in the last big cycle of gully erosion in the Southwest during 1850-1940.

Grazing continues on Forest Service lands above the Abe, Unit; however, the District's range manager is working with ranchers to avoid excessive animal numbers and provide guidelines for best management practices. The grass cover appears good in the headwater watersheds in those areas where relatively good soils remain (field observations in 1996). Grazing was discontinued in the Abe) Unit itself three years ago, and vegetation has made a substantial comeback in the riparian areas of the Unit. In fact, the increasing vegetation now means that a fire management plan should be developed.

Erosion over the decades upstream has likely decreased infiltration and increased peak surface runoff in the Canon Espinoso watershed, which would tend to enlarge the arroyo's channel to handle the extra flows. The late park ranger and locally-born resident Frederico Sisneros remarked that in his over ninety (90) years of residence at Abo he thought the arroyo channel had widened some (Rancier, 1986). The main arroyo (east of the ruins) cuts through areas where the channel appears to be down to Ab6 bedrock layers. Cottonwoods are growing well along some of the arroyos, especially the main one. A bedrock channel or healthy cottonwoods are both indicators of a channel that is basically stable in its conformation.

Some sheet and gully erosion is still occurring inside the northwestern part of the AbO Unit. The park has done some work to stabilize gullies and slopes in this area and to fill in some old flagstone mining scars. The largest arroyo west of the ruins has eroded down to bedrock, so has essentially cut itself into a stable configuration. This larger arroyo originates about 4 miles upstream, so has the potential for powerful discharges (Figures 5 and 7).

Erosion is active along the small, unpaved road that enters the unit's north boundary, close to the main arroyo (Figure 7), where surface runoff from the road and adjacent fields is concentrating and causing rilling. Installation of more drainage breaks along the road would be valuable, to spread out the runoff and break its concentration. A series of broad-base dips across the road could serve this purpose. Sediment also fills in the cattle guard, so a drainage ditch could be useful there as well.

No data are available on how much sediment in fact comes from the large Canon Espinoso watershed upstream. The Natural Resources Conservation Service estimates that in the general 226 square mile Ab6 Arroyo area (which also includes Canon Espinoso) sediment could average about 0.65 acre-feet/square mile/year (average of their 0.50 for Abo formation; 0.80 for Yeso). This estimation is based on the sediment estimation technique of the Pacific Southwest Interagency Committee (PSIAC). The PSIAC technique is a rating based on tabulating points on a score sheet, where points are assigned and summed on the general characteristics of: surface geology, soil texture, storm intensity, runoff intensity, land slopes, amount of ground cover, land use (grazing, roads, etc) and erosive condition of channels. So the estimation is crude in that it does not use actual observed sediment or hydrologic data; but it does make use of soil, geologic, map, rainfall and land-use information and field observations. The figure provides only a general estimation for Canon Espinoso watershed. They also estimate the sediment would be about 70 percent fines, 20 percent sand and 10 percent gravel. Gully and channel-bank erosion is described as "active" in the area. (NRCS, 1996; Woida, 1996).

Generalizing with the above NRCS numbers, an <u>estimate</u> would be that the 20.1 square mile Canon Espinoso watershed would <u>potentially</u> yield 0.65 acre-feet/square mile X 20.1 square miles = about 13 acre feet of sediment theoretically passing by the Abo Unit in an "average year."

Looking at another modelling effort in this part of the State, in 1994 the U.S. Army Corps of Engineers calculated theoretical sediment yield estimations for the entire upper Rio Grande Basin, which includes the greater Abo Arroyo watershed as well (237.6 square miles of watershed in their study). Canon Espinoso is only a minor sub-catchment area within their large-scale model (Corps of Engineers, 1994). The Corps used the Modified Universal Soil Loss Equation to predict wash load (suspended load) sediment, and used a package of transport analysis calculations for estimating bedload (materials moving along the streambed), with a major storm event approach. For the 237.6 square mile area studied, they calculated that a 100-year storm would produce about 0.5 acre-feet of sediment per square mile from the Ab6 Arroyo area for wash (suspended) load and about 1.9 acre-feet per square mile for total sediment load (the difference between wash and total loads being bed load). Based on these values, then a spectacular 100-year storm in the Canon Espinoso would produce far more sediment than an "average year," as would be expected, or about 1.9 acre-feet/square mile X 20.1 square mile = about 38 acre feet coming out of the watershed in a 100-year storm event.

5-WATERSHED MANAGEMENTACTIVITI ES

Salt cedar *(Tamarisk pentandra)* has been invading some stream areas throughout the Canon Espinoso watershed, including the arroyos inside the Abo Unit boundary. The park has been cutting the salt cedar and painting the stumps with glyphosate ("Rodeo") to control the regrowth, with moderate success in controlling or keeping back the trees. This control work will continue, and the park is interested in ideas for better control techniques.

The Natural Resources Conservation Service (Mountainair and Albuquerque Offices), the Cibola National Forest and the Rocky Mountain Forest and Range Experiment Station of the Forest Service have identified the problem of over-dominance of one-seeded junipers in the general Abe, Arroyo area and the resulting erosion, hydrologic impacts and other problems. In a nutshell, the core problem is overgrazing long ago, which caused less grass cover and the over-dominance of junipers --hence less erosion protection. Even removal of cattle does not restore the vegetative balance, and grasses cannot come back until the junipers are thinned out.

They have therefore proposed a 144,446 acre watershed restoration project, with work to begin in 1997 (NRCS, 1996; Cibola National Forest, 1994). Goals include reduction of junipers and enhancement of rangeland cover in order to decrease erosion, improve forage, enhance water supplies from springs, reduce sediment, enhance wildlife habitat and bring about other benefits.

The proposed NRCS/FS restoration project area overlaps the western part of the Canon Espinoso watershed and butts up to the boundary of the Abe, Unit, as shown by the "project line" on the map in Figure 5. The park would benefit by cooperation on this effort, and it may be even be possible that test blocks of the treatment could be tested in the western edge of the Abo Unit --where some surface erosion is seen.

6- SURFACE RUNOFF AND-FLOODING

Rain in this part of New Mexico area occurs mainly as summer thunderstorms, often producing intense runoff. Looking at the soils map in Figure 6 again, the stoney, shallow-soil areas in the upper watershed can be expected to convert a high percentage of storm rainfall into surface runoff. Consequently, it is not surprising that strong runoff is sometimes seen in the Abo Unit following storms in the headwaters of Canon Espinoso miles upstream —especially if a storm moves southeasterly along the length of the watershed. During winter, less intense rains and melting snows have a better chance of infiltrating.

Hydrologic data are not available, but personal observations help provide some insights. The late park ranger Frederico Sisneros observed flooding over the years (he referred to 1912, 1950 and 1985). The Park Archeologist also noted in 1986 during some excavation work that gravel lenses he found could be indications of pre-historic or early mission era flooding in the area as well --but this is only speculation. Floods affect the road into the monument at the low water crossing, which has been up to 6 feet deep in flood water on extreme occasions, according to memory of local residents (the road crossing is 500 feet south of the Visitor Center in Figure A.3).

In 1985 the U.S. Army Corps of Engineers conducted flood plain studies for the park's Abo and Quarai Units, based on maps and calculations. Details of these studies and the maps produced are given in two reports (Corps of Engineers, 1985a, 1985b). No significant dams are in the Canon Espinoso watershed, so flood storage was not a consideration.

The Corps calculated peak discharge estimates for various events, using procedures contained in the U.S. Geological Survey's manual "Techniques for estimating flood discharges for unregulated streams in New Mexico," Water Resources Investigation 82-24 of 1982, and using the COE's HEC-2 computer program. They then used the discharge calculations to map the 100-year floodplain within the Abe) Unit. Peak storm flows determined for the lower end of the main arroyo, at the NPS boundary, were: Two-year storm = 275 cubic feet per second; 5-year = 680 cfs; 50-year =2,800 cfs; and 100-year = 3,950 cfs.

Flood risks at the Abe) Unit do not appear extreme on viewing the Corps' map. The 100-year floodplain map for the Abo Unit shows the ruins and buildings at about 10 feet higher than the 100-year event for the main arroyo to the east and the second arroyo to the west. The ruins also sit on a relatively flat area where any flood waters would spread out and reduce velocities and force (Figure A.3). This may explain why past floods did not destroy the area, as far as is known. The principal arroyo at Abe) also has some characteristics that are favorable from a flooding perspective. The ruins lie on the inside of a curve in the main arroyo, and cutting normally does not occur on the inside of stream curves. Secondly, the arroyo appears to now flow mainly along sandstone bedrock in the area east of the ruins, not so much in erodible materials.

Mature trees are found in the channel environs. These features all suggest that meandering or active bank erosion should not be factors exacerbating local flooding.

7- WATER YIELD SPECULATIONS

No stream gaging data exists in the Abe) or Canon Espinoso area, and no surface hydrology information exists the Manzano Mountain area relevant to the Canon Espinoso drainage basin. During 1916-18 some streams on the east side of the Manzanos were monitored, including an arroyo about 11 miles north of the Abo Unit near the town of Manzano. A few instantaneous measurements also were made on some arroyos in that same area and several miles north in 1985-87 --but during a reportedly dry period (White, 1994). Those limited data offer no useful insights.

The arroyo exhibits a near permanent, albeit normally small streamflow, and at places the flow goes under ground. The area around the ruins is arid; however, the watershed extends about 12 miles upstream up into the edge of the Manzano Mountains to nearly 8,000 feet, where precipitation could be up to 20 inches. The arroyo maintains enough trickle to support pools with riparian vegetation such as cattails (Floyd-Hanna et al, 1994), and a steady inflow is confirmed by the presence of macroinvertebrate organisms and small fish in these pools (Pittenger, 1996) and from observation by local residents over the years (interviews, 1996).

Lacking any data, some crude flow estimations can be attempted. Natural Resource Conservation Service estimates an average annual water yield of about 0.1 inch/acre for the 226 square-mile Abo Arroyo watershed (which mostly lies lower than Canon Espinoso) and about 0.5-2.0 inches/acre from the wetter Manzano Mountain area (NRCS, 1996). Since the Canon Espinoso watershed starts in the Manzanos at nearly 8,000 feet and goes down to about 6,000 feet, then about 1.0 inches/acre might be a reasonable estimation based on NRCS's figures, since Canon Espinoso lies in the middle between of their low (0.1) and high (2.0) range (1.0 being an average of these). Such an__ estimation would then be: 20.1 square miles of watershed X 640 acres/square mile = 12,864 acres X 1.0 inches/acre X 1 foot/12 inches = 1070 acre feet annual yield, which also converts to an average flow of about 1.5 cubic feet per second.

An estimate of the amount of baseflow (the flow other than during storm runoff periods) also can be attempted. Some hydrologists in the area assume that about 2.5 to 5 percent of precipitation infiltrates in these areas of the Manzano foothills, mostly during the winter-early spring when evapotranspiration is low (Fleming, 1996; Smith, 1957; and White, 1994). Assuming the conservative 2.5 percent value and a 17 inch precipitation average for the 12-mile long watershed, then 17 inches X 0.025 [= 0.43 inches infiltration] X 12,864 acres X 1 foot/12 inches = 455 acre feet as annual yield of baseflow in the arroyo (which converts to an average of 0.6 cfs flow). This estimation of course also makes the assumption that the infiltration within the watershed eventually becomes flow in the arroyo and does not include the major component of storm runoff; however, it provides a rough estimate of what dry-period flows may be. The low estimate of only 2.5 percent of precipitation that infiltrates is reflection of the exceptionally high evapotranspiration in this windy, arid region.

"Underflow" in arroyos is common in the area, according to U.S. Geological Survey geologist Zane Spiegel, who studied the area immediately adjacent to Canon Espinoso in the 1940s and 50s. He noted that surface streamflow seeps into the alluvial fill of arroyos, then reappears at other points, and that during storms the arroyos also add recharge to the ground water. Cooler temperatures observed in the arroyo's water at a few points in the Abo Unit also indicates that springs are entering the stream at places (John Pittenger, State of New Mexico, and Sam Kunkle field observations, 1996; Spiegel, 1955).

The process of disappearance and reappearance of a stream also is consistent with a three-day "gain-and-loss" study conducted on an east Manzano Mountain stream about 21 miles north of Abe) in 1985 and 1987. It is common in the Manzanos (Smith, 1957). The study determined that streamflow can either grow or shrink as the arroyo descends from the mountains and the stream seeps into the ground or ground water emerges and adds to streamflow (White, 1994).

8- HISTORIC WATER VOLUMES

Is water yield from Canon Espinoso the same as in the past? The Abo spring (ojo), now in the Sisneros inholding in the Abo Unit (Figure 7), has been described by historians as: "for centuries...a favorite stopover for travelers...because of the good water." The spring was a basis for settlement by Indians, missionaries and families at least since the early 1600s. The spring still is a dependable supply for the family. When the Atchison, Topeka and Santa Fe Railroad came in and needed water for their steam engines, the Sisneros family sold water to them, signing the first lease in 1909 and continuing the contract until 1959. A small concrete dam was constructed (still visible), and a three-mile long pipe transported water to the railroad at Scholle. Locals with long family history at Abe) seem to think that the arroyo does not get the big storm flows of decades ago and that although the spring at the Sisneros is still a good one, it probably "does not flow as much as before" (Sisneros, 1996).

The Natural Resource Conservation Service speculates that the increased number of pinon-juniper (P-J) in the area has reduced water supply to the spring. These trees transpire larger amounts of water. Also, the higher runoff on eroded P-J surfaces decreases the infiltration needed to recharge springs. (Note the PJ watershed management project discussed above in the Watershed Management Section).

In addition, saltcedars *(Tamarisk pentandra), which* are notorious water wasters, are invading some arroyos in the area and "advancing upstream," according to the NRCS (1996).

9- GROUND WATER AND WELLS

Several springs are found in the Canon Espinoso watershed and on its periphery, many intermittent. Springs occur in the Manzano area where relatively impervious beds prevent or restrict further downward subsurface movement of the water and it comes to the surface (Smith, 1957). Since the Yeso and AbO Formations come together at the Abo Unit, as discussed under the Geology Section above, this could relate to existence the Sisneros Family spring. The spring also is close to the alluvial fill' material in the channel, which presumably carries water. The Sisneros spring, on their property inside the Abo Unit, is reportedly of good quality, and has supplied all their domestic and garden irrigation needs dependably over the decades, even during droughts (personal communication, E. Sisneros, 1996).

Ground water in the area typically is moderately to very hard.; Wells draw from the Yeso or Abo Formations, and where the water has passed through gypsum layers of the Yeso, it is usually high in sulfate as well as being hard in calcium. In general, ground water from the east slope of the Manzano Mountains is suitable for domestic use, although hard, but still better quality than Yeso ground water further east toward Gran Quivira (Smith, 1957; Clebsch and Titus, 1960).

In general the Abo and Yeso Formations in the area offer a reasonable potential for deeper well development, as already demonstrated by the wells at the NPS's Quarai unit (Abo Formation; Smith, 1957) and its Gran Quivira unit (mainly Yeso Formation; Clebsch and Titus, 1960). A similar well could be developed at the Abo Unit, which is located at the interface of the same two geologic formations (Yeso lies above the Abo).

In places in the Abo area, wells have even demonstrated artesian pressure. For example, a well drilled for the railway at the nearby town of Abo in 1907 went to 135 feet in the Yeso Formation, and the water rose to within 50 feet of the surface. At 384 feet they hit another water-bearing formation, presumably the Abo, and the water rose to within 25 feet of the surface. Salt water was encountered at about 1,000 feet (Smith, 1957).

Reviewing the limited available records from the U.S. Geological Survey (USGS, 1996), wells in the area are both shallow and deep. For example, some wells are in the alluvial fill area in Abo Arroyo:

- two miles south of the nearby town of Abo a well (02N.06E.Sec9) in since 1916 has a 26 foot depth;

- in the town of Abo a well (03N.06E.Sec29) in since 1940 has a 50 foot depth;

- two miles SE of Abo town a well (03N.06E.Sec34) in since 1950 has a 22 foot depth.

Further east, wells tend to be deeper since the Abo and Yeso Formations slope further underground, for example:

- about 7 miles east of AbO town a well (03N.07E.Sec2O) in since 1950 has a 147 foot depth;

- a well on the NE edge of Mountainair (04N.07E.Sec32) has a 193 foot depth;

- about 7 miles NE of Abo town a well (04N.06E.Sec26) in since 1949 has a depth of 340 feet.

Generally continuing eastward wells are still deeper, and out toward Gran Quivira 500-700 foot depths are common, tapping into the Yeso Formation and sometimes into fractured limestone layers within the Yeso. Water supply wells for the Town of Mountainair are taken from the Yeso Formation as well. The ground-water levels in the area are basically stable (Wilkins and Garcia, 1995).

10- WATER QUALITY, WATER SUPPLY AND WELL WATER RIGHTS

The Abo Unit has a shallow well in the alluvial aquifer, which is not adequate as a public water supply and only used for the employee rest room. The visitors use outhouses, which are pumped out, and they are provided with bottled water. This shallow well's water has demonstrated positive coliform counts, and questions have been raised about possible contamination of the shallow ground water, but the source is unknown. The park should take occasional fecal coliform samples to detect any problem in the arroyo (which is best done during low flow periods in arroyo pools when dilution is least).

In 1994 Hydrogeologist Mike Whitworth of the New Mexico Bureau of Mines and Mineral Resources analyzed inorganic chemicals in the water from the Abo Unit Visitor Center's well and at two surface water sites in the nearby arroyo. These data are shown in the six tables of Appendix D. The chemical quality looked good, and none of the measured chemical parameters were found to be above the Safe Drinking Water Act standards (Whitworth, 1996).

Environmental Protection Agency's STORET data for some wells in the general area provide indication of water quality in the area, as shown in the tables of Appendix E. The tables show that generally the well waters south and east of the park are hard and in cases above the acceptable taste or even health risk level for sulfates. Some sites have 1800 ppm sulfates, for example --three times the sulfate risk level (Flora et al, 1984); such water is only for cattle willing to drink it.

However, the wells about 4 miles west of the Abo Unit --Numbers 1-6 in the Appendix E tables-- are much better quality. The poor quality wells presumably are drilled only into the upper Yeso Formation (which is heavy in gypsum), while others are down into the older and better quality Abo Formation or into layers of limestone within the formation. When drilling a new well at Abo Unit, it obviously is important to have a hydrogeologist on hand to interpret the drilling, to tap into the proper level.

The NPS Southwest Region's Hydrologist in the 1970s recommended that the Monument obtain water rights for the Abe:, Unit (1975 letter in the NPS files), and in 1996 the Water Rights Branch of the NPS Water Resources Division (WRD), Fort Collins again noted "no documentation on water rights" for the Abo Unit (one-page correspondence August 2, 1996, A. Hautzinger, Fort Collins). In other words, the WRD has no documentation in its files concerning the shallow well by the Visitor Center, at least one abandoned well inside the boundary, the spring in the inholding and perhaps other water sources. Since therefore at least two wells are located in the Unit, documentation should be obtained to determine their ownership. If it is found that the National Park Service owns these wells a determination is then needed to see if the rights are in good standing with the State Engineer --before the NPS proceeds with a water rights application for a new Visitor Center well.

The Public Health Service routinely monitors water supplies and has recommended that an adequate well be drilled at Aber (Sacoman, 1996). A well should in fact be straightforward to survey and drill successfully, judging by the information on wells, ground water and geology summarized in this report.

11. SOME DATA NEEDS

Data on aquatic biology for the stream is lacking. In 1996 State of New Mexico Aquatic Biologist John Pittenger visited the unit and noted that some of the arroyo's pools confirm permanent moisture, given the presence of cattails and other wetland plants and aquatic vegetation (Pittenger, 1996). It would be valuable to identify which aquatic organisms are present, and this could be done in conjunction with such a study at Quarai. At the same time, it would be valuable to identify what bird species are utilizing the riparian zone in the Ab6 Unit.

THE QUARAI RESOURCE UNIT

1- CANON SAPATO WATERSHED OVERVIEW

The Quarai unit consists of 99.6 acres located about one mile southwest of the village of Punta de Agua and 8 miles northwest of the town of Mountainair. The unit lies in the center of the upper watershed of Canon Sapato (Figure 8), a catchment with a distinct arroyo, several permanent springs and a well-vegetated riparian zone. The Indians and early explorers knew the site as a refreshing oasis in the midst of dry expanses, and the springs were certainly a key attraction to the Spanish missionaries in the 1600s.

The upper watershed of the Canon Sapato is squarish-shaped basin draining eastward into the closed Estancia Valley. This upper Canon Sapato watershed drains an area of 2.7 square miles. The Quarai Unit is located roughly in the center of this watershed, and the principal springs lie in about the middle of the Quarai unit. The springs are presumably fed by the sub-area of the watershed above them, which is 1.7 square miles in size (Figure 8).

The highest elevation on the Canon Sapato divide is 6970 feet, the lower boundary of the Quarai unit is at 6580 feet and the outlet of the upper Canon Sapato watershed, near the Punta de Agua cemetery, is at 6495 feet. The main channel of the Canon Sapato, from the upper watershed's upper extreme down to its mouth near the village cemetery traverses a distance of 2.6 miles. The fall in elevation therefore is 475 ft over a 2.6 miles distance, which is a drop of 182 foot per mile (or 3.5%) along the principal arroyo's channel.

The upper reaches of the watershed are mostly in private ranching lands and reportedly intensively grazed. Flashy stormflows enter a small arroyo the unit's northwest corner, producing some gullying and sediment, indicating that soil conservation upstream is not adequate (Figure 8).

The springs of Quarai produce a small but dependable flow that supports an estimated 5 acres (perhaps more) of riparian and wetland area within the unit as well as another estimated 2 acres immediately downstream from the NPS's boundary. These wetland areas have not been delineated, so the acreages are only conservative estimates based on field observations.

The wetland zone serves as a critical habitat for birds and wildlife, provides a place to appreciate the richness of plants and is a valuable area for environmental education, especially since wetlands in this ecological zone are so scarce. A survey of birds in the Quarai unit has identified over 100 species, underscoring the richness of the ecosystem (Pineda, 1996). The natural resources of Quarai therefore are a distinctive and vital part of the unit and its mission.

A decade ago during a drought, a fire swept through the unit's picnic area, killing many of the large cottonwoods. Fires will continue to be a risk at times, and a fuel hazard reduction effort will necessarily continue to be a component of the unit's management and planning.

2- CLIMATE, GEOLOGY AND GEOMORPHOLOGY

Climatological data are not available for the unit, but Quarai's location is only about 8 miles from the town of Mountainair and at approximately the same elevation, so the unit's climate is similar to that of Mountainair, described under the "General Hydrology and Climate" section and illustrated in Figure 4.

The red sandstones and shales of the Permian Abo Formation crop out in the vicinity of Punta de Agua village and nearby Quarai and are distinct in the incised arroyo just below the footbridge. The Abo geologic formation is described above in the "General Geology" section of the Introduction chapter and in detail under the "Climate and Geology" section in the Aber chapter.

Below the footbridge (near the "springs" on Figure 10), the arroyo has made a ravine for a stretch of about 500 feet, at places over 20 feet deep. Except for some minor bank sloughing in places, the ravine's erosion is not particularly active, as evidenced by decades-old trees and a well-established vegetation along most of the ravine reach and by the dense plant growth in the wetlands immediately below the ravine. The arroyo has cut down to the hard Abo Formation layers at a series of points along the stream, creating a series of rock "weirs" and plunge pools. This staircase of pools dissipates flow energy, backs up small ponds and probably dams up the alluvial material that supports the wetlands.

In view of the hard substrate found in the channel, further downward cutting would be unlikely; however, some minor bank sloughing would be expected to continue, especially when unusually severe storms strike. Local inhabitants also confirm that the arroyo's basic configuration and size have stayed about the same during the memory of their lives --which in some cases is back to the 1930s (interviews D.ChacOn and T.Gonzales, 1996).
For a period up until about 1938 or 1939 a pond reportedly was maintained in the upper end of the arroyo, but this washed out and was not restored (comments in notes of 1939-40 excavation work by Wesley Hurt). Possibly an earlier acequia also used a pool near the present springs to divert irrigation water (discussed below under Acequias).

The arroyo was probably less incised a few hundred years ago. For example, what appears to be old rock work ruins is found on the ravine's north side dangling over the top edge of the cliff, more than 20 feet above the channel. Perhaps these rock structures were part of a older diversion, a dam or a stream-side building? A larger channel could have been created by upstream impacts, such as grazing, in the upper reaches of the watershed. The impacts would have reduced grass cover and compacted the soils, which caused erosion, then reduced infiltration and increased storm surface runoff. The resultant higher runoff with its more powerful flows then would have cut the arroyo down to today's size and shape, to handle the larger flow volume. Simultaneously the springs would have lost some of their flow, since recharge of ground water also would have been reduced with the lower infiltration. If this speculation about ancient land-use impacts is true, then the springs' flows would have been somewhat stronger when the early Spanish missionaries first saw them, and parts the riparian area would have been more accessible than today. Possibly soils in the general area also would have been less eroded than now and more appealing for irrigation and farming.

3- VEGETATION

Vegetation in the Quarai unit is diverse and for this part of New Mexico rich in the number of plant associations. Floyd-Hanna *et al.* (1994) surveyed the vegetation and distinguished 17 associations at Quarai, for upland, near-riparian and wetland areas. The wetland and riparian associations mapped along the principal arroyo contain cottonwoods (two species), bulrush, sedges, gambel oak, poison ivy, junipers, roses, currants, cattails, barberry, blue gramma, western wheatgrass, and a variety of flower species.

Drier upland areas contain common pH-ion-juniper woodlands and grasslands, with sagebrush, saltbush, yucca, cacti, and the grasses common to the middle and upper Pinon-Juniper Belt, plus isolated ponderosa pine, mountain mahogany and gambel oak --more indicative of the lower edge of the Pine-Oak Belt. Domestic and exotic plant species in the unit include apple, chokecherry, wild plums, kochia and various small weeds and forbs. Some of these plants reportedly came in with Civilian Conservation Corps planting projects of the 1930s. An impressive thicket of poison ivy is found in the wetlands near the east boundary of the unit. The Floyd-Hanna *et al.* (1994) maps also are available in a GIS format.

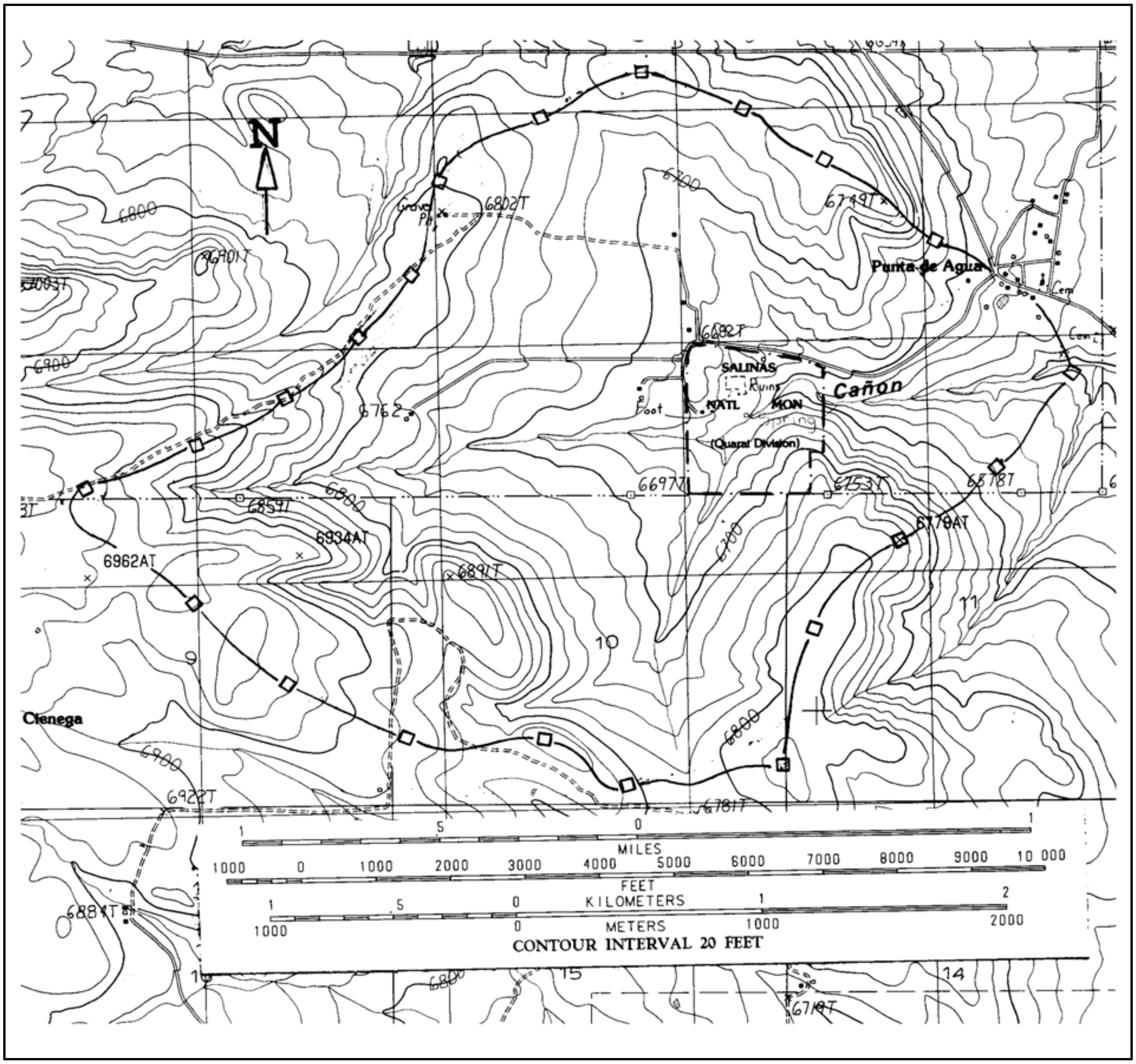


Figure 8. Overview of the Cañon Espinoso watershed, showing its drainage divide, watershed mouth (at right edge), Quarai Unit boundary and location of the nearby village of Punta de Agua.

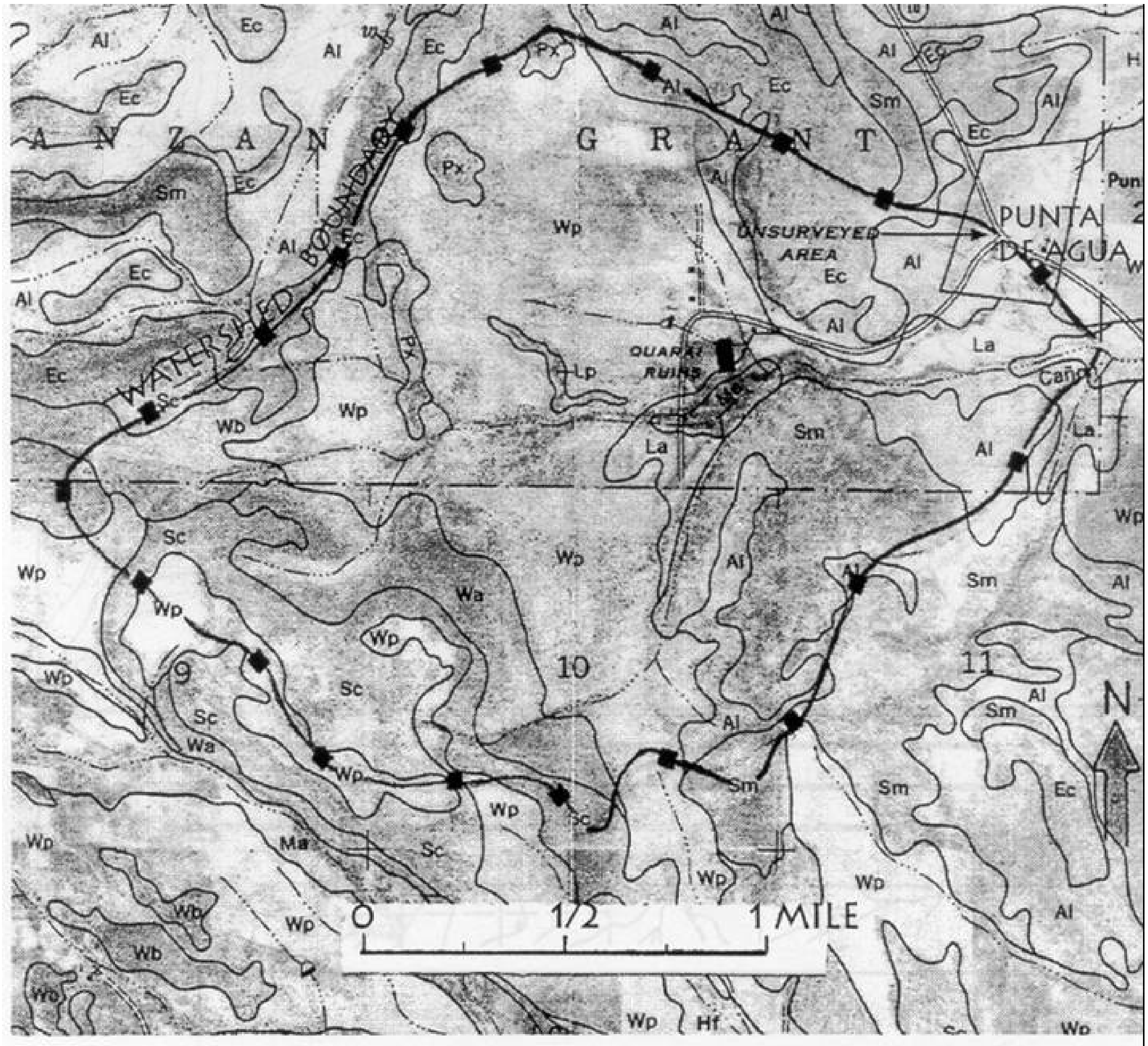
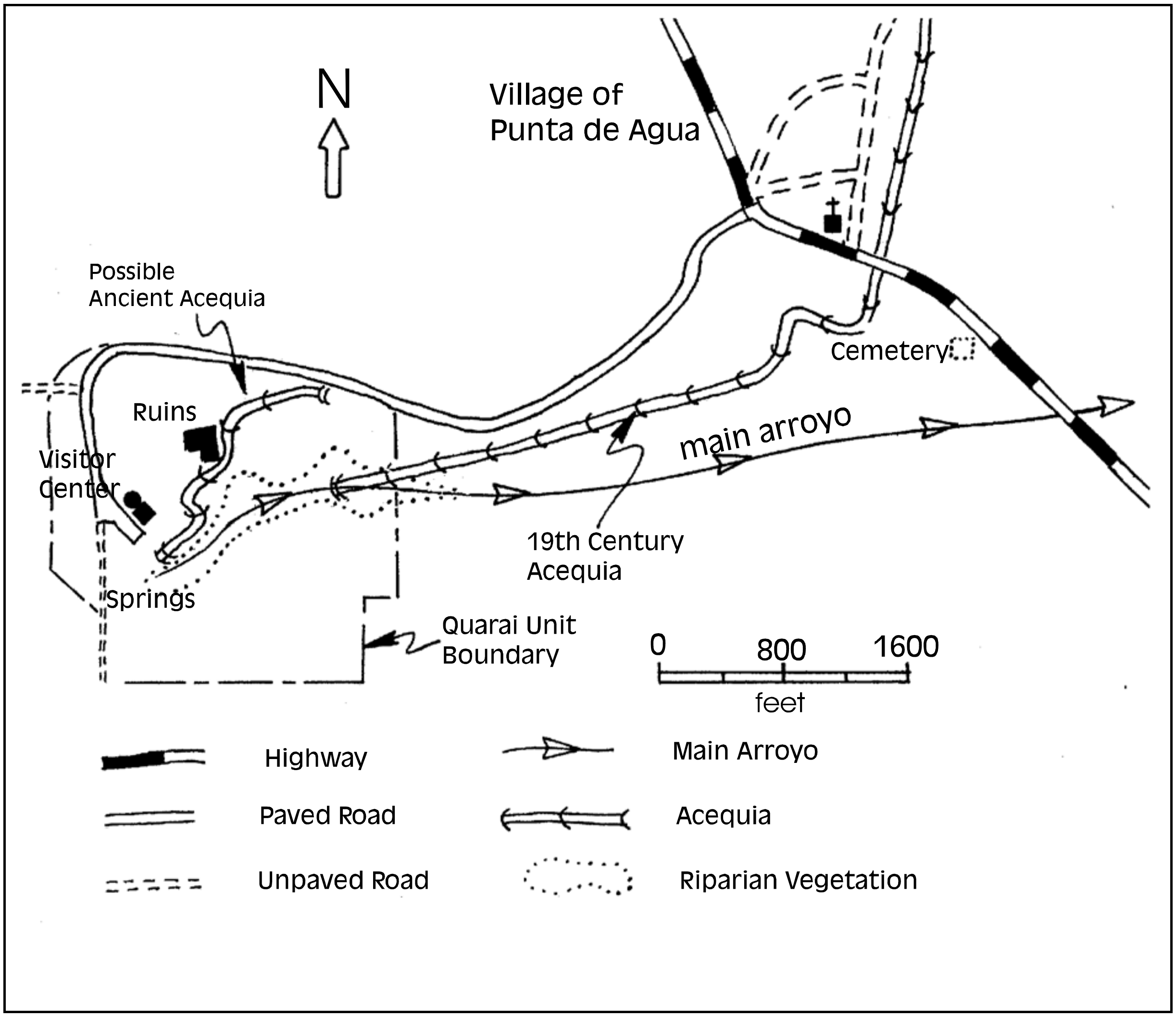


Figure 9. General soils map for the Canon Sapato watershed at the Quarai Unit, based on Soil Consrvation Service (natural Resource Conservation Service) map of the county (Bourlier et al., 1970). Ec = Encierro channery loam; Sc = sholle gravelly loam; Ma= Manzano loam; La= Pinon channery laom; and Lp = laport rock outcropcomplex. Descriptions are avalible in Boulier, 1970.

Figure 10. The Quarai Unit and its water resource features.



4- SOILS, EROSION AND SEDIMENT

No detailed soils survey has been conducted for the Quarai unit; however, the 1970 general soils map for the Torrance Area by the Soil Conservation Service --now Natural Resources Conservation Service-- allowed preparation of the overview map of soils in the upper Canon Sapato watershed presented in Figure 9 (Bourlier *et al.,* 1970).

As the map shows, the upper ridges and the southeastern part of the Quarai unit are dominated by rocky soils, with rills and "erosion pavement" on the surface in the midst of scattered junipers and a poor vegetative cover. Some of these areas have received past impacts from grazing, and the post-grazing effects continue. Once grazing affects the vegetative equilibrium in ecosystems of the arid Phnon-Juniper Belt, simply removing the animals does not stop the erosion cycle, as extensive research underway in the pinon-juniper at Bandelier National Monument has shown (Wilcox et al, 1996). Erosion washing away artifacts also is a problem at Bandelier and a potential concern at Salinas as well.

The NPS presently is cooperating with the Natural Resource Conservation Service on restoration of some eroded ph¯ion-juniper areas adjacent to the Abo unit, as discussed above in the Abo chapter (NRCS, 1996), and some of those restoration techniques could be reviewed for relevance to some eroded sites in Quarai as well.

A small arroyo feeding into the northwestern corner of the Quarai unit is producing gullying, contributing sediment to clog the drainage ditch along the north side of the ruins. Unfortunately this runoff and erosion is the result of upstream impacts on non-NPS land above the unit, so continuing to clean the ditch of sediment is the best immediate park action for this problem.

The flatter areas in the Quarai unit consist of more loamy soils (Figure 9), including: the Alicia, La Fonda, Manzano, Pinon-Channery and Witt loams; and Washoe cobbly loam. Characteristics of these particular soils and their occurrence in the Canon Sapato drainage can be seen in the detailed maps of the Torrance Area soil survey book (Bourlier *et al,* 1970).

In the wetland portion of the unit, the lush vegetation is presumably rooted in alluvial material derived from upland erosion and sediment. The geologic map of the area also shows that just below Punta village soils are generally classified as alluvial materials from geologic erosion (Figure 2).

5- SURFACE RUNOFF, ARROYO FLOW AND FLOODING

The Canon Sapato arroyo is ephemeral along most of its route to the Estancia Valley. The arroyo maintains a steady trickle of water for a quarter to a third of a mile below the Quarai Unit's springs, supporting the lush wetlands found there; however, below the village the stream usually goes underground --except for stormy periods-- and wetland species are not evident.

No gaging station exists, so the flow of the main arroyo or its springs have not been monitored, other than a few sporadic measurements made by the U.S. Geological Survey at the highway below the village in 1987, where they measured from 0.2 to 6.0 cubic feet per second (Shomaker, 1996). These isolated data provide no insights. Consequently the arroyo's discharge can only be described with estimations.

During and after storms, strong flows can appear in the arroyo, sometimes overtopping the culvert and flooding the highway below the village of Punta de Agua (Figure 10). Inside the Quarai unit, water in the bottom of the main arroyo below the footbridge commonly rises three feet or more deep during intense storms, as observed by staff and shown by remnants of storm debris.

Using available maps and their HEC-2 computer program, the Corps of Engineers predicted the theoretical storm surface runoff at the bottom edge of the Quarai unit would be 77 cubic feet per second for a 2-year event, 376 cfs for a 10-year event and 1,480 cfs for a 100-year event (COE, 1985), confirming that adequate runoff can exist to account for the "several feet of depth" seen at times.

A small arroyo feeds into the northwest corner of the Quarai unit (Figure 10) and flows around the northern edges of the mission ruins at times. This small arroyo drains about a square mile and can produce brief periods of localized flooding next to the mission ruins, flowing at about 12 cubic feet per second for a 2-year storm, according to the Corps of Engineers calculations (COE, 1985a, 1985b).

The COE study map and report also provide predictions of flood levels at points around the Quarai unit. During a 100-year storm, for example, water is predicted at about half a foot deep around the perimeter of the ruins and in the parking lot area. The park staff maintains a ditch along the north boundary of the ruins. The Quarai unit's superintendent noted that in 1976 a big storm brought water into the diversion on the north and west side of the mission ruins, and because of sediment in the ditch some overflow occurred, showing the need to regularly clear the ditch of sediment (Salinas correspondence, Fulfer, 1985).

6- AQUATIC BIOLOGY AND THE WETLANDS

The unit has no data on aquatic organisms, although the wetlands vegetation has been at least generally surveyed, as noted above under the "Vegetation" section, and the bird species have been identified (Pineda, 1996).

In a brief visit in 1996, a State of New Mexico Aquatic Biologist, John Pittenger, was impressed with the diversity and abundance of organisms in the small ponded areas and ripples along the main arroyo. His brief visit revealed: dragonfly (order *Odonata);* damselfly (order *Odonata);* mayfly (order *Ephemeroptera);* beetles of the order *Coleoptera,* including a *Gyrinidae;* water strider (order *Hemiptera, Gerridae* family); caddisfly (order *Tricoptera);* leech (class *Hirudinea);* scud (an amphipod); frog (amphibian) and various types of algae. This preliminary snapshot confirms that the arroyo's water routinely must contain good oxygen levels, nutrient conditions and temperatures in order to support these organisms --several which are indicators of a healthy aquatic environment. The presence of an aquatic population also confirms the permanence of the springs' flow. A rich aquatic ecosystem also attracts birds. A complete survey of aquatic organisms would determine what other organisms are present.

In places, the riparian vegetation could be managed for improvement. For example, one species of bulrush over-dominates the area by the footbridge and poison *ivy* is thick in part of the wetland. Expert advice on ways to manage for a good wetland and riparian plant mixture would be useful to the park.

Note that the Clean Water Act includes Section 404 on "wetlands," a point discussed under Section 11, Wetlands and Acequia.

7- HYDROGEOLOGYAND SPRINGS

A geologist writing about the southern Manzano Mountain area noted, "Water perched on a slightly permeable stratum often moves downdip to emerge as springs where arroyo alluvium is thin or absent over shallow bedrock...or where erosion has dissected the aquifer below the perched-water surface. Similarly, springs occur where erosion intersects the main water table" (Spiegel, 1955). This has some relevance to the setting at Quarai, where the Ab6 Formation with its dark red sandstone, siltstone and shale is close to the surface as it dips eastward off the Manzano Range. Presumably a layer serves as a lens to catch percolated water in a shallow aquifer and guide it out as springs and also to maintain the shallow water table found at only about 10 feet under the mission ruins. Rock layers also are seen at the surface in distinct layers running across the arroyo's incised channel, resisting erosion.

The Abo Formation contains deeper water-bearing layers as well, and the formation is reported to be about 300 feet thick (Chronic, 1987). The <u>deeper</u> strata presumably extend well beyond the bounds of the small Canon Sapato watershed, and most likely are recharged from higher up in the Manzano Mountains according to Smith's studies (1957).

Solid flow data of the springs or of the arroyo are not available; however, the springs' flow is known to be dependable. According to locals long *in* the area, even in the droughts of the 1950s the springs continued to run, and reportedly the springs never dry up (communications, M. Romero and T. Gonzales, 1996). Also as noted above under the section on Aquatic Biology, some organisms found in the water confirm a permanent flow. The cottonwoods by the picnic area are indicators of the shallow water table.

The springs quite possibly do not run as strong as in generations past. For example, a pond and windmill existed just northeast of the mission ruins in the early 1900s, where remnants of the old pond are seen. The old spring (referred to locally as "Ojo de Pino"), which is now fenced off, was reportedly a bigger spring earlier in this century (interview, T. Gonzales, 1996). The park has interest in cleaning up this spring area, perhaps by installing a more attractive fence. One can speculate that watershed impacts upstream have reduced spring recharge, as discussed above under Climate and Geology.

Only approximations of spring or arroyo flow are possible, lacking actual data. A crude approximation can be based on the estimated amount of infiltration multiplied by the watershed area, with some assumptions. First, because the Aber Formation slopes eastward at Aber (Chronic, 1987) and the watershed's surface slopes in the same direction, or essentially along the same plane, assume that the surficial watershed area approximates the contributing area for the shallow aquifer of the springs. Secondly, an estimation for the average rate of recharge of precipitation must be assumed. Some hydrogeologists (Smith, 1957; White, 1994; Fleming,1996) suggest about 0.5 inch per year in this area or about 2.5 to 5.0 percent of the precipitation to be a rough rule of thumb of percolation (Note that this value is so low since most rainfall in the area falls in the dry and hot summer when high evapotranspiration and storm surface runoff rob most of the rainfall). A third assumption is that most of the percolating water from storms is caught at the shallow aquifer and then moves along some hard layer to the springs. Keeping these limitations in perspective, then an <u>estimate</u> of the springs' average flow would be as follows:

> 1.7 square miles (or 1088 acres) of contributing watershed area above the springs X 0.5 inch (or 0.04 feet) of percolation or recharge = 45 acre feet of water annually, or averaging about 0.12 acre-feet/day or 0.06 cubic feet per second or an average of about 28 gallons per minute (gpm) for the springs together. Naturally individual daily values would vary enormously from this daily "average," depending on weather conditions.

Asa comparison, the coordinator for the Punta de Agua Ditch Association, T. Gonzales, noted in an interview that technicians form the State of New Mexico came by once many years ago and pumped at a rate of 20 gpm in a pond below the main spring area and observed that the pond "continued to stay full." He also noted that sometime in the 1960s a Vista Volunteer in the area set up a temporary flume and actually measured the main spring's flow some, and he believes that "as much as 85 gpm were seen in some of the high flow periods" (T.Gonzales interview, 1996).

Reportedly as many as 1500 people lived in Punta prior to the railroad's arrival and the attraction to move to Mountainair. Assuming the 1500 were in the village, in say 375 households, then the crude estimate of 45 acre feet of water annually would have provided only about 0.1 af/household/yr. This is a small volume compared to 0.25 - 0.33 af/household/yr recommended for some subdivisions today; however, unlike today, roof cisterns and runoff-harvesting dams across arroyos were widely used in the area before the 1940s and were presumably supplementary water sources.

8- GROUND WATER AND WELLS

As discussed above under Hydrogeology and Springs, the geologic formation at Quarai has shallow as well as deeper water-bearing strata, with the deeper layers no doubt extending beyond the bounds of the small Canon Sapato watershed. The U.S. Geological Survey (Albuquerque office) has measured the depth of water in the National Park Service's well for over 20 years, with no significant fluctuations evident:

Year of Measurement	Depth to Water
1973	20.92 feet
1976	22.75
1977	23.44
1979	23.34
1980	23.28
1981	22.06
1985	23.55
1990	21.05
1995	20.93

The National Park Service's well at Quarai is 90 feet deep (the U.S. Geological Survey data records it as 98 feet deep).

A private well about a mile west of Quarai

(04N.06E.Sec04) shows a similar depth to water, at 18 feet deep (USGS records). The nearby well for Punta de Agua village is 180 feet deep and serves 19 hookups in the village (D.Chacon, 1996). A private well at 200 feet deep in Punta de Agua village reportedly yields "good water quality" (M.Romero, 1996). A private well about 3 miles southeast of the village of Punta de Agua (04N.07E.Sec08) is drilled deeper (240 feet), and shows a fairly constant water level from USGS measurements during 1973-95, fluctuating up and down from 71 to 79 feet below the surface. Some climate-related fluctuation is natural.

An abandoned well for the town of Mountainair still somewhat further southeast (04N.07E.Sec23) is regularly monitored by the USGS and shows water levels from 112 to 133 feet below the surface, with generally a fluctuation of only about 5 feet per year. As these data show, moving eastward into the Estancia basin, ground-water tables are generally deeper, and since the geologic formations slope downward in an eastern direction, this would be expected. The data do not show any trends or declines in water levels (USGS data).

9- WATER QUALITY, WATER SUPPLY AND WELL WATER RIGHTS

Water Quality: The Public Health Service monitors water supply for the Quarai unit to assure safe drinking water. The water comes from a 90-foot deep, drilled well located just north of the visitor center, as noted in the preceding section. A submersible pump serves to draw water into a 1000-gallon storage tank, where it is chlorinated. Bacteriological sampling is regularly conducted to insure absence of coliforms and provide for potability. Occasional chemical samples determine that the water meets the requirements of the National Primary Drinking Water Regulations (Sacoman, 1996). An example of chemical data from the well appears in the tables of Appendix F, showing 31 constituents analyzed which confirm the water as meeting acceptable standards. These analyses show essentially a pH-neutral water of modest hardness, low metals and good clarity.

In 1994 Hydrogeologist Mike Whitworth of the New Mexico Bureau of Mines and Mineral Resources analyzed inorganic chemicals at two sites in the surface water emerging from springs and flowing along the main arroyo at Quarai. As shown in his data in Appendix D, the water flowing in the arroyo is of very good quality, slightly alkaline, relatively hard, low in sulfates (unlike many deep wells in the area), relatively low in the alkaline earths and nitrate and acceptable for the metals observed (Whitworth, 1996; Flora *et al,* 1984). Because nitrate and chlorides in the samples are so low, it also implies that the springs are not polluted by chemicals from fertilizers, animal or human wastes at this time (These are two chemicals that move readily through soils and ground water and can be "tracers" for these kinds of impacts).

Few "STORET" data from the Environmental Protection Agency are available in the immediate area, but data from a shallow well at 18 feet to water (site 0003) about a mile west of Quarai shows a hard but otherwise acceptable water for domestic use. The Appendix E tables summarize EPA data from wells in the general five-mile radius.

Water Rights: Correspondence from the Water Resources Division of the National Park Service (Hautzinger, 1996) shows two referenced wells in the area: (1) a Punta de Agua Domestic Water Users Association well at SE1/4,SE1/4,Section 2, T4N, R6E, Permit No. E-314 and originally 400 feet (which appears to be outside the Unit's boundary); and (2) a Museum of New Mexico well at NE1/4, SE1/4, Section 3(projected), T4N, R6E, Permit No. E-1648 and originally 300 feet, in the Unit. The Punta de Agua Domestic Water Users Association has a permit for 4.5 acre feet of water per year, according to the system operator (interview D.Chacon, 1996). The application for the E-1648 Permit from the Museum of New Mexico is dated February 26, 1969 and is the standard application for 3 acre feet, requested for the caretaker's residence and visitors' center at the "Quarai Ruins State Monument."

An evaluation of records from the State Engineer's Office and other sources is needed, to determine the extent of the National Park Service's water rights for the Unit for wells and for surface water from the springs. Note that water rights also are discussed below in respect to the acequia.

10- THE.ACEQUTA

It is not certain at this time when the first acequia (irrigation system) appeared in Quarai or who was involved at the early stages. The Spanish knew about water diversions and irrigation systems from the Roman Empire days, or earlier, as still seen in the Roman aqueduct in arid Segovia and other ruins in Spain. The Spanish naturally brought these traditions to arid missions such as the Quarai site. It also is known that some Indians of the Southwest used "rainfall catches" and even did some flooding of fields (Lopez and Schuller, 1996; Toulouse, 1943).

What originated as a 19th-Century acequia operated in Punta de Agua until 1972, and was managed by the Punta de Agua Ditch Association. The location of this acequia is shown on the map in Figure 10. Its intake point was about 100 feet from the present downstream boundary of the Quarai unit, in the midst of what is now a wetland thicket. A trace of the ditch is still visible for much of its length, and some locals still know its path, but gradually erosion and vegetative growth are covering the evidence of this piece of Quarai history (Lopez and Schuller, 1996).

The ditch's water was used for growing beans as well as for domestic use, but with installation of a deeper and better town well in the early 70s, the ditch was abandoned. Some older locals in Punta are still officially members of the Association (interview, T. Gonzales, 1996).

The coordinator for the Association, Tobia Gonzales, notes that the ditch was first registered with the State in 1845, but he understands that this was some 25 years after this ditch was first initiated (interview, T.Gonzales, 1996).

A map from 1920 by Engineer E.M. Fenton and registered with the State Engineer's Office shows "22 acres of irrigation," broken into 22 tracts of 1 acre, with a user's name for each of the tracts. This is reportedly the earliest map locals know of the acequia (T.Gonzales, 1996). This map includes text on its face and lays claim to, "2.5 acre feet of water per acre delivered on the land, for which claim is hereby made for irrigation purposes." A State Engineer's Office stamp on the map shows receipt and Declaration No. 0394 to 0412, May 5, 1920 certifying the filing of the map. Note that the 22 acres X 2.5 acre feet/acre = 55 acre feet per year total is actually more water than this report's estimate for the springs' annual yield calculated above under the "Hydrogeology and Springs" section above, namely about 45 acre feet/year. It is not known how much water in fact was delivered in a typical year.

Did the Spanish mission have an acequia even earlier, perhaps in the 17th or 18th Century? Questions over the history of acequias at Quarai has inspired a group of five cultural and water resource scientists and scholars to propose additional research into the origin and history of Quarai's irrigation. At this time their research is only in the preliminary stage, pending additional funding for the work.

The group is researching the possibility of an older mission acequia, where the Padres of the 17th century may have dammed up some water in the seep area (above the present footbridge), lifted the water and irrigated with it, probably also using a pond in the area just northeast of the mission ruins. As yet no written record about such an acequia has been found and the hypothesis of the existence of such an earlier acequia is based mainly on stories of the productivity of crops and animals at Quarai, on the knowledge of an acequia at the Tajique Mission during the same period and on Lopez's study of excavation notes by archaeologists in the 1930s and 40s (Lewis, 1995; Lopez and Schuller, 1996). Also a 1913 map sketched by an unknown archeologist or history student illustrates the traces of an old ditch running near the ruins with its intake point at the upper end of today's main arroyo, that is, some 1,200 feet upstream from the intake of the 19th Century acequia. What did this artist know in 1913? In other words, the speculation is that a 17th-Century system lay considerably upstream from the 19th-Century acequia, as shown in Figure 10. Many of the fields theoretically irrigated by this older acequia, if it existed, are now eroded, gullied or taken over by weeds. Since the soils near the mission probably were not eroded when the Spanish came, it is logical that irrigation of the fields close to the mission would have been attractive.

Some of the village inhabitants have interest in re-establishing the acequia they used up until 1972, for sake of producing trees or other crops (Marcos Romero, *et al* 1996 interviews). The village water supply also is stretched to its capacity at this time, so irrigation water from the springs via an acequia could help take some strain off the village system (D.ChacOn, 1996 interview).

The Tonantzin Land Institute, an organization in Albuquerque, also has discussed the concept of restoration of an acequia with local inhabitants This institute assists communities throughout the Southwest with a mission "to promote and preserve traditional ways...through community advocacy... (with focus on)...educating groups about their land and water rights." (Tonantzin, 1996; David Lujan).

The park is open to discussion on the question of acequia restoration, and naturally has interest in the acequia from a historical and interpretive perspective and in terms of retaining good relations with the local community. The NPS also could have an interest in water from the acequia if the NPS purchased land from former user(s) of acequia water. At least two key questions relate to the restoration idea. First, it is not clear at this time exactly what entity or entities retain the water rights for the acequia. The Association obviously had rights, but has not exercised these rights for over 20 years. The park should seek a legal opinion from the Office of the Solicitor on these complex questions of water rights related to the acequia.

The park clearly needs some additional help on all these legal questions; therefore, a "Project Statement" on this topic is provided in Appendix A.

11. WETLANDS AND ACEQUIAS

A question relates to wetland ecology, since potentially re-establishment of an acequia would eliminate most of the water below its intake point, at least during growing season, thereby likely eliminating some wetlands and presumably affiliated animal or bird species downstream from the intake point. Since the 19th Century intake for the acequia is quite close to the NPS downstream boundary, restoration of this 19th Century acequia would probably relate only to lands downstream from the park and not be a detriment to wetlands inside the park. If, however, some water were diverted further upstream, then the park's wetlands would no doubt be affected.

Note that the Piro-Manso-Tiwa Indian Tribe (Pueblo of San Juan de Guadalupe) expressed the view that "wetlands are vital to the ecology...and the species of ancient life... (and) have aboriginal rights to the lands and water resources" (letter to the Park from Louis Roybal, Governor, January 30, 1997). This perspective also must be taken into account during any water rights study.

The Clean Water Act includes Section 404 regarding "wetlands," and any management activities at the Quarai unit that would affect 1/3 acre or more of wetlands —especially any diversions or other action that would reduce them-- would need review by the Corps of Engineers' state coordinator for wetlands, with review and approval by the Environmental Protection Agency, Fish and Wildlife Service and the State of New Mexico. A Section 401 water quality certification must be obtained from the New Mexico Environment Department as well. A large number of bird species also use the wetlands at this time, so any impact on them also would be considered in the review. The park has an estimated 5 acres or more of wetlands at Quarai. Contacts for these regulations are shown in Appendix B.

THE GRAN QUIVIRA RESOURCE UNIT

1- GRAN QUIVIRA OVERVIEW

The Gran Quivira mission and pueblo ruins are located on top of a wind-blown mesa, with broad, long-distance views of the mountains and plains in all directions. The rectangular-shaped unit, which contains 611 acres, is located about 25 miles southeast of Mountainair on Highway N.M. 14.

The unit sits on the escarpment of Chupadera Mesa, which is just outside the southern edge of the closed Estancia Basin. Storm or snowmelt runoff and infiltration from the unit disappears into the closed Tularosa Basin, which tilts to the south. The surface drainage is poorly developed, and the unit has no permanent surface water, springs or distinct arroyos --as found at the other two units. A spring east in the Gallinas Mountains, about 13 miles from the site, is reportedly the nearest permanent surface water (Chronic, 1985). The sparse vegetation at the site reflects the arid conditions of the area (Figure 11).

The elevations in the unit range from 6,310 ft in the southwest corner to about 6,560 ft in the northeast corner, with the ruins posed along an east-west ridge in the unit at about 6,520 feet.

2-CLIMATE, GEOLOGY AND HYDROGEOLOGY

As displayed in Figure 4, Gran Quivira receives large fluctuations in precipitation. The records from 1962 to 1994 show a low of 9.85 inches in the year 1989 to a high of 23.61 inches in 1986 (NOAA databank, 1996). About 70 percent of the precipitation in the area occurs during the period April-September, when evaporation is greatest (Smith, 1957).

The Gran Quivira ruins are unique among ancient New Mexican Indian and mission structures in having been built of limestone, since the unit lies on a mesa surfaced with San Andres limestone and a thin layer of sediment. The limestone also contains the gypsum and salt which flavors wells and sometimes harms potability.

The land surface around Gran Quivira is a rolling karst topography, and the surface features reflect the solution of the limestone which underlies the entire area. Valleys in the Gran Quivira vicinity are characterized by scattered sink holes, resulting from the solution in the gypsum that constitutes much of the rock at the surface (Bates, 1947; Clebsch, 1960; Chronic, 1987; Smith, 1957). Some of these sink holes are larger and contain pools of water several acres in size, at least in wet periods; they are referred to as playas.

What summer precipitation is not lost to the high evapo-transpiration becomes ground-water recharge and percolates down into sink holes, crevices and solution channels into the limestone and gypsum cap of the limestone member of the San Andres formation or further into the underlying Yeso Formation (Smith, 1957; (Figure 2). In the 1920s, before wells came into common use, these playas, the damming of arroyos and cisterns played a major role in holding surface water to help ranchers survive dry periods (V. Wells interview, 1996). By the 1940s, wells were common. Captured rainwater still remains chemically much preferable to the sulfate-high gypsum water found in some wells of the area.

3- VEGETATION AND SOILS

A vegetation study was conducted in 1979 by Earth Environmental Consultants, Inc. of Albuquerque, using aerial photographs and field checks to identify the plant communities and their distribution within the Gran Quivira Unit (Pache, 1979). The unit lies in the Upper Sonoran Life Zone, containing juniper woodlands and shrub-grasslands, with some 25 grasses, 32 forbs and 16 trees/shrubs. Some well-known species most evident include one-seed junipers, tumbleweeds, sagebrush, saltbrush, gramma grasses, yucca and cholla cactus.

In 1970 the Soil Conservation Service completed its Torrance Area Soil Survey Report, which covered essentially the northern half of the unit (Bourlier et al., 1970). The SCS (now NRCS) provided some additional interpretation for the National Park Service on the Gran Quivira Unit, noting the following highlights. A soil survey for the unit also was conducted in 1979 by an Albuquerque consulting firm (Lopez and Cox, 1979).

The unit's soils fall into two mapping units, the Chupadera loamy fine sand and the Otero and Palma soils (Figure 12). The Chupadera soil covers essentially the crests and slopes in the unit. These are more rocky soils and not particularly good for septic disposal fields. The Palma and Otero soils are better for sewage disposal. Details on these soils are found in the SCS report and its maps, based on aerial photographs (Bourlier *et al.,* 1970; Wilborn, 1970) and in Lopez and Cox (1979).

Soils are naturally subject to erosion from both the dry winds and occasional pounding by thunderstorms. Some small rills and gullies appear throughout the unit, although many of these cuts appear to be down to harder rock, so presumably somewhat stable on the rock base. Possibly grazing in the distant past upset the plant equilibrium and favored expansion of junipers over grasses —an impact which exerts its effects for generations after the grazing has ceased (Wilcox et at, 1996).

Some erosion is present along the entrance road. The road was originally designed in a straight line up the hill, perpendicular to the hillslope, creating a long roadside ditch which concentrates runoff and produces high erosive force. The park recognizes the design problem and the need to either increase culverts or other measures to spread the runoff, or to install drop structures along the ditch to break the water's force.

4- GROUND WATER, WELLS AND GROUND-WATER QUALITY

The San Andres limestone which is widely exposed around the Chupadera Mesa and exposed at the surface is underlain by Glorieta sandstone, which in turn is underlain by the Yeso Formation. Recent alluvium covers the older rocks in the valleys.

The Yeso Formation, which is the principal water-bearing formation, is not visible at the unit. The Glorieta is white to yellow sandstone, while the San Andres formation contains gray limestone, plus yellowish or white sandstone and white gypsum (Bates et al, 1947). The Glorieta and San Andres formations are not generally water-bearing layers in the area. Around the Gran Quivira area the Yeso Formation may be as much as 1,000 feet thick (Clebsch and Titus, 1960), and the great depth to water plus the possibility of finding high sulfate levels in water from the Yeso formation makes well development a challenge.

Wells are generally in the Yeso Formation, mostly at about 400-900 feet deep. Clebsch and Titus (1960) summarized some examples of well depths in the local area, all down to Yeso sandstones and lime rock, and listed:

- 710 foot well to the south;
- 840 foot well to the southeast (J.Kite well);
- 875 old NPS well (with a 3,800 mmho/cm conductance);
- 710 foot well to the north (Fulfer well);
- 710 foot well to the north (Connell well);
- 637 foot test hole by Titus for NPS, 1958.

Records attained from the Geological Survey (USGS, 1996) also show mostly similar examples well depths in the area, for example:

- a 500 ft well at 1 N.8E.Sec 04;
- an exceptional 50 ft shallow well, 1 N.8E.Sec33 (Kite ranch);
- a 480 ft well to the east at 1 N.9E.Sec28;
- a 650 ft well to the southeast at 1 S.8E.Sec32

Water quality varies enormously, depending on the particular stratum tapped, according to hydrogeologists Clebsch and Titus (1960). For example the second well (at 840') above has only 45 ppm sulfate. Conversely the older NPS well had an extreme chemical level, as shown in the very high specific conductance of 3,800 micromhos/cm -- not fit to drink.

Environmental Protection Agency STORET data (in Appendix E) summarizes water quality data at 9 wells within 2 miles of the Gran Quivira unit and shows sulfates —the main quality concern-- in the 9 wells from 45 to 2,500 mg/L, with a median sulfate value of 713 mg/L. Levels above 500 mg/L are generally not recommended for regular consumption (Flora et al, 1984), although up to 1,000 is not usually harmful, just not palatable, and some people are sensitive at 400 mg/L (WHO, 1984). Hardness in these same wells ranges from 200 to 2,200 mg/L with a median hardness of 870 mg/L, which is not harmful.

5- WATER SUPPLY AND QUALITY AT THE UNIT

The unit's present 638 foot well is about one and a half miles southwest of the Visitor Center and drilled through the upper San Andres layer down into the Yeso aquifer. The well taps about 25 feet of bearing Yeso stratum and maintains a water table at about 612 feet deep (Clebsch and Titus, 1960; Sacoman, 1996). The well is able to deliver a good supply, potentially up to about 50 gallons per minute according to Moore (1982), and the present 10 gpm pump from 1985 now provides adequate water to a 50,000-gallon tank northeast of the visitor center to ensure a supply. The water is tested routinely and is "safe" by the National Primary Drinking Water Regulations, although in the 1995 test relatively high in sulfate (696 mg/l) and high in total dissolved solids (1545 mg/l) and hardness (830 mg/l) --as for most wells in the area in the Yeso formation. The water is chlorinated. Bottled water is provided at the visitor center. Installation of a softener has been discussed for the staff residences (Sacoman, 1996).

Septic tanks and drainfields serve the visitor center, maintenance building and housing units and are functioning satisfactorily but in need of some minor repairs, as summarized in the Public Health Service inspection report of August, 1996 to the Superintendent (Sacoman, 1996)

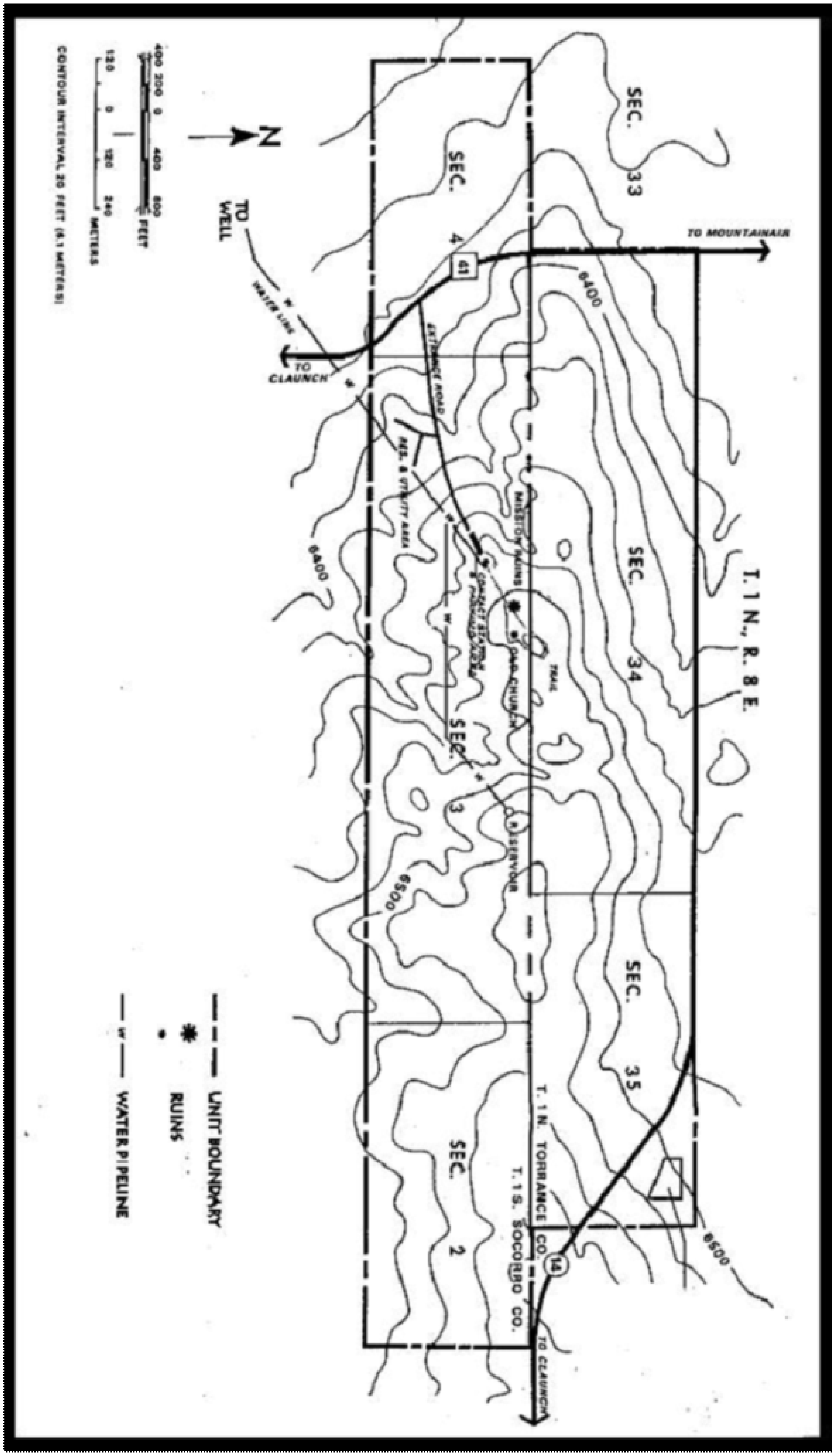
6-WATER RIGHTS

Documentation is available at the NPS Water Resources Division offices describing the conveyance of lands associated with the well to the United States. The water rights for the well at Gran Quivira is based on a deed and easements for well, pipeline, power line and access road on the adjacent J.L. Kite family land. The deed was filed on November 5, 1959 in county Volume 208 of Miscellaneous Records at page 195. The Office of the Attorney General file number is 33-32-255 (in correspondence from Office of the Attorney General, Washington [W.P. Roger], to Secretary of the Interior [F.A. Seaton], on September 10, 1959 and January 15, 1960), in records on file with Water Resources Division, Fort Collins. However, there is no documentation from the State Engineer's Office in WRD records concerning a State water right for the well. Such documentation is needed in order to assure that the State acknowledges this NPS water right. Since the NPS acquired land from the public domain at Gran Quivira, does the park have Federal reserved water rights for park purposes? These water rights questions need clarification.

7- HISTORIC AND PREHISTORIC WATER SUPPLIES

Archaeologists have long speculated: What did the ancient Indian culture of 1,500 persons or more at Gran Quivira use for a water supply in the midst of a largely waterless region —in contrast to the Quarai and Ab6 sites where surface water was present? Various theories have been pondered as to how they found water, up until they presumably abandoned the region during a 1660 to 1672 drought period (Toulouse, 1943). Possibly in ancient times the climate was somewhat wetter, so that the playas in the region also retained water longer or perhaps some springs ran. Modern well drilling in the general area has revealed pieces of pottery at 30-40 feet or more at some sites, inferring that older, hand-dug Indian wells were in fact likely. If the Indians transported in their water, the known spring about 13 miles away would have been a long trek, but not so different from what some east Africans and Nepalese regularly do today. Some archaeologists theorized that the Indians had a system of runoff catchments, ditches and reservoirs; and perhaps such a system, if it existed, stemmed from the Spanish Franciscans. Howard (1959) notes that no evidence exists to support this theory, but that shallow wells were probably used, without ditch systems. So the question is still open on what water supply existed either in pre-historic or during mission times —a topic perhaps intriguing for further research.

Figure 11. Overview of the Gran Quivira Unit.



RECOMENDATIONS

Some of the recommendations summarized here also correspond to the Project Statements in Appendix A.

1. HYDROLOGIC AND WATERSHED DATA FOR ABO AND QUARA/ UN/TS:

Basic information on climate, soils, erosion, stream water quality, sediment and streamflow is lacking for the Ab6 and Quarai Units. Therefore, one of the **Project Statements** included in Appendix A recommends technical assistance to the park to design and help initiate the collection of some basic, low-technology measurements of watershed and hydrologic data for the park managers, to help generally quantify erosion, any pollution, major precipitation events, average stream and spring discharges and to quantify the extremes in flows for these two units. (See Ab6 Sections 7-8 and Quarai Sections 5 and 7).

2. *SO/LS fOR ABO AND QUARA/ UN/TS:* A basic soil survey for the Ab6 and Quarai Units is

desirable. (See Ab6 Section 4 and Quarai Section 4).

3. AQUATIC B/OLOGYAND DATA FOR ABC) ANDQUARA/ UNITS:

Routine information on stream aquatic biology is lacking. Therefore, a **Project Statement** in Appendix A recommends technical assistance to the park to conduct at least a limited aquatic biological survey for the Ab6 and Quarai Units, to define the species present to genus level, to identify any species of particular interest or rarity and to provide the park with a basic collection of the specimens. At least an approximate delineation of the Quarai wetland area should be completed at the same time (See Ab6 Section 11 and Quarai Sections 6 and 10).

4. INSTALL A WELL ATABO:

Development of a deep well for the Ab6 Unit has been recommended by the Public Health Service, and this report concurs (presumably the park could use the site either as a Visitor Center or as a rest room by the ruins for a number of years to come). This report's fairly complete review of ground-water literature and local wells indicate that an adequate well is attainable at the unit. However, due to the high complexity of the area's geologic formations (as discussed in this report), it is essential that a geohydrologist or geologist be part of the well drilling and exploration, to insure desirable water quantity and quality. A **Project Statement** in Appendix A recommends geologic technical assistance to the park for well exploration and development. (See Ab6 Section 10)

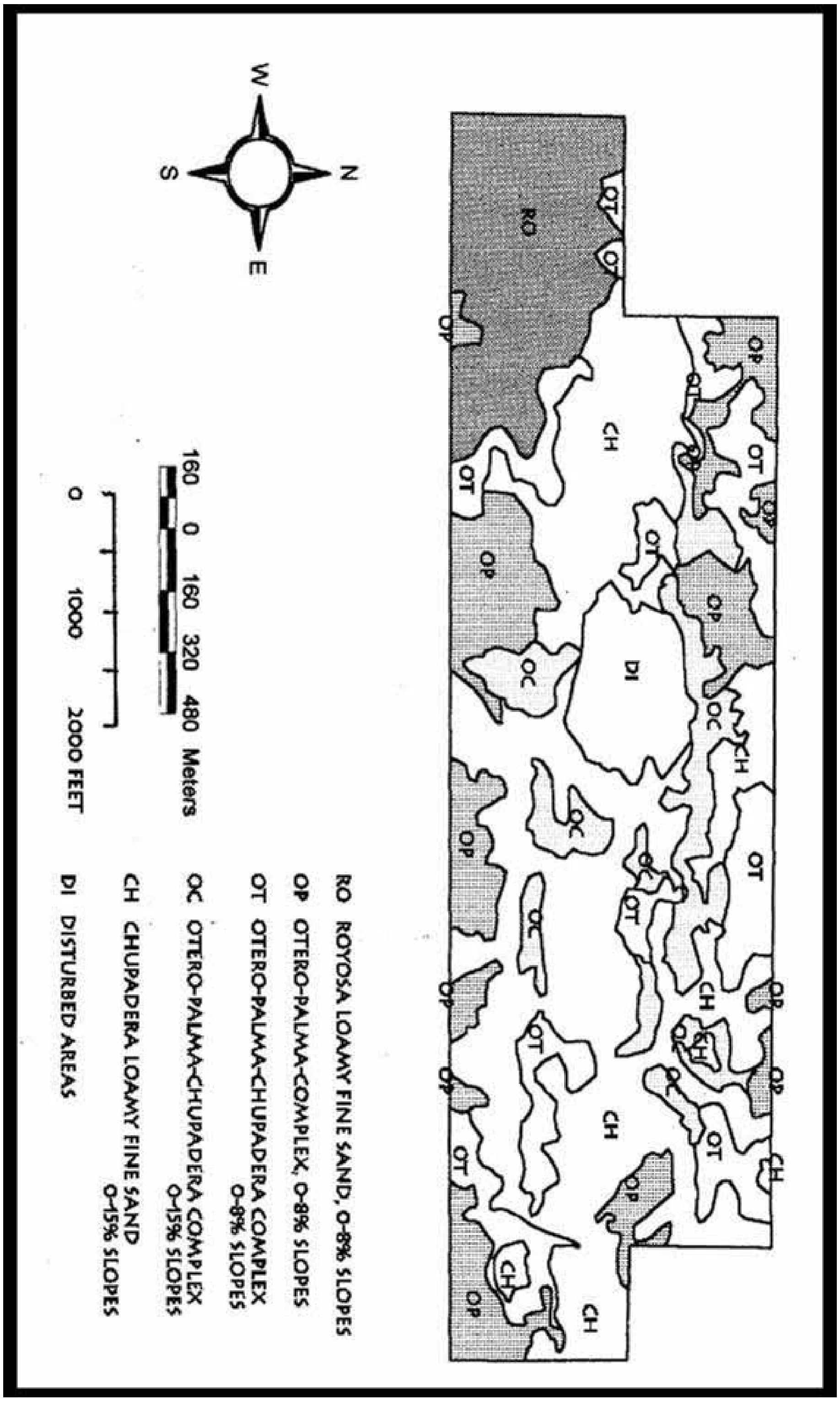
S. WATER RIGHTS:

There is little documentation available concerning the water rights at all three park units. To assist in protecting the park's water supplies, information is needed on existing water rights for all the wells, springs and the acequia. A **Project Statement** on this topic therefore is included in Appendix A.

A. More information is needed on the water rights and water quality of shallow wells and springs at Ab6. This clarification is needed prior to application for a new well there.

B. At Quarai, water rights related to the acequia is the prime concern and a topic that could move to the legal front burner at any time and involve delicate questions of water rights, public relations and possible effects on the wetlands. It is not known if the NPS has any responsibility to assist in restoring parts of the acequia, should

Figure 12   Soils in the Gran Quivira Unit.



the acequia restoration be pursued by the water users; therefore, the park should seek a legal opinion on this point from the Office of the Solicitor.

C. There is no documentation from the State Engineer's Office on file in NPS Water Resources Division records in Fort Collins concerning a State water right for the well at Gran Quivira; therefore, such documentation should be filed, in order to assure that the State acknowledges this NPS water right. Since the NPS acquired land from the public domain at the Gran Quivira Unit, does the park have Federal reserved water rights? These points need clarification. If the gathered information shows that the NPS does not have water rights for water it is using, then the NPS must take steps to ensure that its uses and rights are properly recorded with the State Engineer's Office.

D. The park needs to follow up on these water rights issues with the Water Rights Branch of the Water Resources Division in Fort Collins (Chuck Pettee, Acting Chief at 970-225-3535), particularly on the acequia issue at Quarai.

6. WATERSHED MANAGEM ENT

A. The park's efforts to control the salt-cedar invasion along the Abe) arroyos should continue, since many salt cedars are found outside the unit and will continue to re-invade. The park needs some technical advice from a person having solid experience on the ground specifically in this topic and could benefit by a short visit by such a person; therefore, two experts were contacted in early 1997 and are listed in Appendix B's table under Deuser, Curt. The park also can use these contacts to network and review other existing federal, state and county programs with examples of effective salt cedar erradication in New Mexico.

B. The park's informal cooperation with the Natural Resources Conservation Service at present on their nearby watershed restoration and juniper reduction project is an excellent and sound idea. This collaboration also should continue and be expanded, since eventually the same restoration techniques that are tested can be applied to selected eroding slopes in the Salinas units --especially at Abo. The park should collaborate on the research by suggesting that one or more Forest Service research plot sites be included in the western edge of the Abo Unit (See Abo Section 5).

C. Erosion control efforts at the Abo Unit can best focus on the smaller gullies and rills and surface erosion, since the larger arroyos in the western part of the unit have flows that are too powerful to manage. Also, the major arroyos are down to bedrock so should not significantly change. Continued use of local rock and brush works well for sediment trapping and reseeding on the local spots, as done, seems appropriate.

D. Minor watershed works and clean-up that would be good to consider:

(i) continue maintenance and some enlargement of the diversion ditch around the ruins at Quarai, to allow more space for sediment; some runoff control work around the parking lot area is planned by the park;
(ii) carry out the park's idea to clean up and put a better fence around the "Ojo de Pino," i.e., the small spring just north of the ruins at Quarai;
(iii) seek expert botanical advice on the general management of the plant cover in the wetlands area at Quarai, for example advice on how to manage the over-dense wetland vegetation near the bridge --to encourage plant diversity, and advice on ways to control the dense poison ivy cover in a section of the wetlands; and
(iv) continue the effort to improve the erosion control on the entrance road at Gran Quivira, probably best done with rock drop structures along the ditch.

7. CULTURAL RESEARCH.-

(i) The question of what water supply existed either in pre-historic or during mission times at Gran Quivira remains a point worthy of further research and valid as a thesis topic for someone. The park may want to request the NPS SW Cultural Resources Center, Santa Fe, to support this cultural research and to facilitate university researchers to work on the topic.

(ii) The question of a possible 17th Century acequia at Quarai continues to be an interesting research topic, and the park should continue its cooperation to seek funding for this cultural research.

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ACKNOWLEDGMENTS

The authors would like to acknowledge Superintendent Glenn Fulfer and his staff at Salinas Pueblo Missions National Monument, whose cooperation, support and many contributions were essential for the preparation of this report.

Special appreciation is extended to: Jim Bates, Range and Resource Manager, the USDA Forest Service, Mountainair; Bill Fleming, Geohydrologist, the University of New Mexico; and John Pittenger, Aquatic Biologist, the State of New Mexico. They generously came out to the field with us to provide invaluable views and interpretations on hydrology, range management, biology and other topics.

Linda Beal of the U.S. Geological Survey, Dean Tucker of NPS Water Resources and Mike Whitworth of the NM Bureau of Mines and Mineral Resources donated valuable time to provide essential water data.

The preparers also would like to thank the many people who graciously provided interviews, ideas, information, reviews or suggestions, including Jim Boll (NPS, Salinas), Donny Chac6n (Punta de Agua), Darrell Eidson (COE), Milford Fletcher and Doug Bradley (NPS, Albuquerque), Eric Galloway and Brian Wirtz (New Mexico Environment Department), Juan Gonzales (NPS), Tobia Gonzales (Punta de Agua), Jack Kite (Rancher, Gran Quivira), Jerry Larson (USGS), Larry Lopez (UNM), Frank Martinez (FS, Mountainair), Lisa Meyer (Mescalero Apache Tribe), Ed Natay (NPS, Santa Fe), Norma Pinada-Prog (NPS, Salinas), Marcos Romero (Contractor, Punta de Agua), Gov. L. Roybal (for the Piro/Manso/Tiwa Indian Tribe), Mike Schneegas (NPS, Salinas), Ernestine Sisneros (NPS, Salinas), Richard Spencer (NRCS, Mountainair), Laurie Schuller (UNM), Vernie Wells (Rancher, Gran Quivira) and Kathy Woida (NRCS, Albuquerque).

Appreciation also is extended to Nancy Skinner and staff of the SW Support Office of the NPS in Santa Fe and to Mark Flora, Chuck Pettee, Jeff Hughes and Rick Inglis of the NPS Water Resources Division, Denver, for their cooperation and support during the project.

APPENDIX A PROPASED PROJECT STATMENTS

Project Statement SAPU-N-015.000 Priority: 3

Title : **Design and Initiate Inventory of Water Resources**

Funding Status: Funded: 0.00 Unfunded: 25.00

Servicewide Issues : N20 (BASELINE DATA)
N12 (WATER FLOW)

Cultural Resource Type: CULL (Cultural Landscape)
N-RMAP Program codes : N00 (Resource and Visitor Use Management)

Problem Statement:

The Background: Water resources have shaped the course of history and archaeology at the Salinas Pueblo Missions National Monument --possibly more than any other factor. The springs and streams found within the Abe) and Quarai Units were no doubt the main attraction that brought Indians to the sites, led to the establishment of ancient pueblo villages, later attracted the 17th Century Spanish padres and finally supported settlers and their animals.

Water at Alai) made it possible to keep animals and graze them in the nearby foothills of the Manzano Mountains. At Quarai, the permanent springs in an otherwise dry area provided the water for an acequia (irrigation ditch system) that was established for farming and domestic uses by at least the early 19th Century. Recently, the local village ditch association has proposed re-opening this acequia.

From a natural resource viewpoint, the springs of the Quarai Unit support an exceptionally rich riparian zone which stands out as an "oasis" in the middle of an otherwise parched landscape, attracting and protecting over 100 species of local and migratory birds and a variety of wildlife.

The Problem: Practical, quantitative information on water and watershed resources is needed for the Quarai and Abo Units in order to manage and protect both natural and cultural resources at the two units. The mission and pueblo ruins of these park units are located near arroyos and springs, and over the years have been subject to hydrologic impacts, including localized flooding, moisture and sedimentation at Quarai, arroyo cutting and surface erosion at Abe), contamination of ground water and other effects.

Lack of Data: The 1997 Water Resources Management Plan for the park confirms that no valid data exist on the flows of the Quarai springs; on the flood peaks, low flows and sedimentation at AbO; or on erosion in any unit. Little is known about water quality. No meteorological data are available for the two units.

Park Decisions: The paucity of water resource data makes it difficult to properly handle issues such as: watershed protection; planning for flood protection around ruins; detection of pollution; erosion control; protection of the biological community of wetlands; quantification of water volumes as a background for water rights issues now rapidly approaching; and interpretation of historical uses of water by the Indians or Spanish Colonial missions.

Cultural Aspects: Cultural resources are directly dependent on water resources, for example, erosion and flooding can destroy artifacts and harm archaeological sites. Hydrologic information is needed for interpretation of the history and archaeology of the area.

In summary, water resource information and data are needed in order to maintain the integrity of the park's natural resources and to protect the closely-related cultural resources.

The Need for Initial, Short-term Support: The arroyo at Aber and the springs at Quarai are minor surfaces waters from the state perspective. The U.S. Geological Survey or State agencies have not monitored these streams, and almost assuredly will not do so in the future because of the growing demands on their time to deal with the many problems related to urban development in an arid state.

The park therefore needs to take a pro-active role in conducting a low-technology observation program to build and maintain an elementary databank on water and watershed resources at the Aber and Quarai Units. Such a grass-roots monitoring program will need to the support of a short-term cooperative project to provide expertise in the beginning, for two years. The short-term project expert would:

(i) conduct essential field measurements and calibrations, in conjunction with park staff; and
(ii) work with park staff to develop a low-technology, inexpensive protocols which park staff can continue to use for their park program and database. Staff training would be part of the short-term package.

This Project Statement lays out a proposal for this short-term project.

Description of Recommended Project or Activity

The park needs a cooperative study to (i) assess its water resources and (ii) to help the park design a low-technonolgy monitoring program and database. A scientist would work in close conjunction with park staff over a two-year period to conduct an evaluation and quantification of water quantity, quality and erosion at the Aber and Quarai Units (the two units with surface waters), mainly using low-tech, inexpensive methods that park staff can continue to use in the future, for example:

(i) calibrated stream cross-sections with basic staff gages; (ii) some hand sampling for some key indicator constituents; (iii) "erosion pins" to observe soil loss on various slopes; (iv) simple peak-flow indicators at stable, rocky arroyo cross-sections;
(v) calibrated photo-points and benchmarks on arroyos to monitor channel cross-section configurations;
(vi) manual rain gages; and
(vii) user-friendly PC-driven software to compile and present information and data in a format suitable for park interpretation and reference.

During the two-year study the scientist would work with park staff to:

(i) characterize discharges and fluctuation for the principal springs, as related to major meteorological events, and quantify the peak, low and typical flows (calibrating cross-sections as needed);
(ii) measure peak and low flows in three arroyos (Abo = 2; Quarai = 1) and relate them to storm events, snowmelt and dry periods;
(iii) evaluate the erosion rates for a range of slopes and vegetative conditions (using erosion pins or other simple devices);
(iv) train park staff to assess sediment delivery during large storms with hand sampling, gravimetric analyses and other low-technology methods;
(v) observe a few, key indicator constituents of water quality to detect any pollution sources and to provide baseline water quality information.

The scientist would produce a report and interpreted two-year data base in a form with practical applications for the park managers. The scientist would design and establish an inexpensive, low-technology monitoring plan which the park staff can continue to use, and would provide training to park staff, so that the park could continue with a program to:

(i) detect impacts caused by a particular water or land uses upstream or land-use changes;
(ii) characterize long-term trends of water quality and quantity;
(iii) evaluate the effects of park management decisions;
(iv) provide information for cultural researchers on the volumes and flow regimes of water; and
(v) provide quantitative information needed as background for any water rights determinations (such as spring yield questions sure to arise at Quarai).

Results from the initial evaluation project and the continuing monitoring program would provide the Superintendent and park staff a data base from which to make more informed management decisions and to protect the water resources in accordance with NPS Management Policies.

Equally important, the project would develop a inexpensive, monitoring program which would include park staff "ownership" in the development, for continued use by the staff.

Such data would benefit all resource-related evaluations and interpretations conducted in the monument, both natural and cultural.

BUDGET AND FTEs:

----------------------- FUNDED -----------------------------

	Source	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	RG-RM-NAT	**RES**	One-time	15.0	0.2
	RG-RM-NAT	MON	One-time	5.0	0.1
			Subtotal:	20.0	0.3
			Total:	20.0	0.3

---------------------------- UNFUNDED ----------------------------

Year	Activity	Fund Type	Budget ($1000s)	FTEs
2:	MON	Recurring	5.0	0.1
		Grand Total:	25.00	0.4

(Optional) Alternative Actions/Solutions and Impacts

No Action. This action would leave the monument without an adequate database to protect its water resources or to understand the relationships between water resources of the monument and early human activities at the site. Water resources might deteriorate.

Compliance codes : EXCL (CATEGORICAL EXCLUSION)
Explanation: 516 DM2 APP. 2, 1.6

Project Statement SAPU-N-002.002 Priority 7

Title : **Assess Riparian and Wetland Aquatic Ecosystems**

Funding Status: Funded: 0.00 Unfunded: 24.00

Servicewide Issues : N20 (BASELINE DATA)

Cultural Resource Type:
N-RMAP Program codes : Q00 (Water Resources Management)
Q01 (Water Resources Management)

10-238 Package Number :

Problem Statement

Background: Although Salinas Pueblo Missions National Monument is located in an arid zone in the Southwest, many of the monument's prehistoric and historic ruins are found next to a floodplain or riparian area. The surface and groundwater sources that currently support riparian ecosystems also served as the water supplies for historic and prehistoric humans. The waters have a key historical significance.

The wetlands and riparian areas in the park offer strong natural resource values as well. A rich assemblage of riparian plants and aquatic organisms is found in the park, especially in the Quarai Unit where wetlands occur downstream from the unit's springs, providing an "oasis" for over a hundred species of birds and wildlife in an otherwise arid land.

Preliminary observations suggest an excellent diversity of aquatic organisms live in the Quarai Unit's wetlands, and a good riparian ecosystem also is found along the main stream in the Ala() Unit. These areas have excellent potential for environmental education use as well.

The Problem: The monument does not have an understanding of its aquatic ecosystems in the Abo and Quarai Units or even know what species of aquatic organisms are present. From a management viewpoint, knowledge of the aquatic ecosystems and related water resources is basic to running a park in an arid zone —where having an adequate and acceptable water supply is always a concern and where wetlands are rare and precious.

The park needs information in order to develop an appropriate program to protect its wetlands and riparian ecosystems and to develop information for visitors' interpretation and environmental education activities.

Description of Recommended Project or Activity

A short-term project is needed to carry out a basic inventory of aquatic organisms and an assessment of the wetland and aquatic ecosystems of the Abe) and Quarai Units. The project would provide for an aquatic biologist to identify and summarize aquatic organisms by species and communities, including:

- (i) the macroinvertebrates, amphibians, crustaceans, fish, reptiles, mammals and other aquatic animals;
- (ii) the aquatic plants, including algae, fungi, larger bacteria and phytoplankton;
- (iv) the periphyton; and
- (v) the macrophyton and flowering plants in the water and saturated zone.

Unusual or rare species as well as exotic or weed species would be noted.

The inventory would include a limited number of relevant physical and chemical analyses for water as well, to aid in interpretation of the biologic data. This would include:

> pH, temperature, conductivity, turbidity, dissolved oxygen, nitrates, alkalinity and the four alkaline earths, calcium, magnesium, potassium and sodium (at four samples per growing season and two winter samples at a total of three-four sites in each of the two units). Streamflow levels and meteorological conditions also would be noted.

The work would take place within a two-year period, with focus on the two spring-autumn seasons.

The study would interpret the information gathered as it relates to hydrology, sedimentation patterns, any pollution or other watershed or land use factors at the two units. In addition, the study's results and interpretations would be linked to any other studies underway in the area involving water or land resources.

Available information on the avian population at Quarai provides opportunity to interpret the relationship of food supply of bird species to the aquatic plants and animals to be assessed in this study. A general vegetation survey of flowering plants also has already been conducted in the units, which includes the riparian zone; therefore some background information exists on the larger, rooted riparian plants. This study would complement these earlier works by providing information on smaller aquatic plants and on food sources of the birds.

The results of the study would be presented as a summarization of the species present and structure of the aquatic communities, using tabular and narrative format. Each species would be described and interpreted in the report as to:

> (i) its role; (ii) particular importance or place in the food chain; (iii) negative impacts (if any); (iii) problems of survival (if any); (iv) role as an "indicator" of water quality or other conditions, such as oxygen level; (v) its adherence to a particular animal or plant community.

At least one common, statistically-based diversity index for the macroinvertebrates would be presented and interpreted. The aquatic ecosystems would be described narratively in plain language in terms of their structural and functional stability, the general health of the ecosystem and any evidence of pollution impacts or other disturbances.

Practical management recommendations for managers also would be included in the final report, including what special management actions are needed for long-term protection of certain species or ecosystems.

A specimen archive would be provided to the park for their reference collection and for interpretation and environmental education purposes. This would include a series of photographs and collection of preserved or dried specimens for at least the principal and indicator species.

BUDGET AND FTEs:

----------------------------------FUNDED----------------------------

Source	Activity	Fund Type	Budget ($1000s)	FTEs
		Total:	0.00	0.00

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	RES	One-time	10.00	0.2
	MON	Recurring	2.00	0.0

		Subtotal:	12.00	0.2
Year 2:	RES	One-time	10.00	0.2
	MON	Recurring	2.00	0.0
		Subtotal:	12.00	0.2
		Grand Total:	24.00	0.4

(Optional) Alternative Actions/Solutions and Impacts

No Action: Manage with insufficient knowledge of existing ecosystem components and process with possible losses to both the natural and cultural landscapes and reduction in visitor satisfaction.

Compliance codes : DOC (COVERED BY ANOTHER DOC)

Explanation: NPS 77

Project Statement SAPU-N-004.000 Priority: 1

Title : **Determination of Federal Water Rights**

Funding Status: Funded: 0.00 Unfunded: 20.00

Servicewide Issues : N13 (WATER RIGHTS)

Cultural Resource Type:

N-RMAP Program codes : Q00 (Water Resources Management)

10-238 Package Number : 129

Problem Statement

Background: The Water Rights Branch of NPS's Water Resources Division has pointed out the need to clarify the water rights status for the springs and water supply at the Quarai Unit and the related, potential acequia use of water; they also noted the need to determine all water rights at the Abo and Quarai Units (correspondence from WRD, 1996 and 1997).

An old acequia (irrigation ditch) has its point of origin inside the Quarai unit of Salinas Pueblo Missions National Monument, where permanent springs provide surface water. The use of the ditch was first registered with the State in 1845 and a request was made to the State Engineer Office in 1925, requesting 2.5 acre feet of water annually per acre for an area of 22 acres.

The acequia use was abandoned in 1972, and the NPS has taken over ownership of the point of origin of the acequia since that time. The local village still has a ditch association whose members formerly operated the acequia, and the association has active interest in rehabilitating this acequia.

An Albuquerque-based group, the *Tonanzin Land Institute,* also has particular interest in the restoration of the acequia. This institute specializes in restoring acequias and has a mission to "promote...community advocacy...(with focus on)...educating groups about their land and water rights."

To further complicate the situation from a regulatory perspective, re-establishment of the acequia and diversion of the water could potentially affect as much as 7 acres of wetlands. These wetlands are ecologically vital to over 100 species of birds and wildlife.

The park also needs to determine its water rights at the Abo Unit, which relates to a shallow well at the Visitor Center, a spring in the inholding and the application for a new, deeper well.

For the Gran Quivira Unit, there is no documentation from the State Engineer's Office on file in NPS Water Resources Division records in Fort Collins concerning a State water right for the well; and such documentation is needed in order to assure that the State acknowledges this NPS water right. Since the NPS acquired land from the public domain at the Gran Quivira Unit, does the park have Federal reserved water rights? A determination of water rights is needed.

The Problem: There is little documentation available concerning the water rights at all three park units. To assist in protecting the park's water supplies and its wetlands, a determination is needed on existing water rights for all.the wells, springs and the acequia (irrigation ditch).

The Water Resources Management Plan of 1997 also confirms that the water rights for the old acequia and for use of the springs is unclear to the local ditch association. The state rules on water rights for abandoned acequias is apparently nebulous. The water rights issue at the Quarai unit raises many questions about ownership of water rights in a complex situation.

Are the acequia rights still valid after 25 years of abandonment? What has happened as land ownership moved over to NPS? If the claims for acre-feet of water by the village and ditch association exceed the actual water available from the springs in a given year, what does this mean for the diversion of water? How do wetland regulations and water rights laws interact if wetlands potentially are impacted by an acequia diversion?

Note that the Piro-Manso-Tiwa Indian Tribe (Pueblo of San Juan de Guadalupe) spokesman has expressed the view that"the tribe does not agree with...restoration of acequias" (at Salinas)....since... "wetlands are vital to the ecology...and the species of ancient life... (and) have aboriginal rights to the lands and water resources" (letter from Louis Roybal, Governor, January 30, 1997.

At best, the Quarai water rights issue will be a complex one, involving discussions among the local villagers, the ditch association, the State Engineer Office, political entities, Indian Pueblos, the NPS and others.

In order for the U.S. to assert its claim to surface and ground waters within the area of the park, and to inform park planners and managers of water legally available for NPS uses, it is necessary to clarify and quantify the complex Federal water rights at both of these resource units. At present the park is not in compliance with the requirements and the long-term provision of water for park use. Some legal involvements and determinations on these water rights issues are inevitable.

Description of Recommended Project or Activity

The park needs support to conduct research on the questions of: existing water rights claims; acequia (irrigation ditch) diversions at Quarai; well and spring water rights at all three units. This work is needed to determine the water legally available to the United States Government in these units, now unclear and subject to conflict. This action also would need to include a determination or best estimation of well and spring yields.

BUDGET AND FTEs:

----------------------------- F U N D E D -------------------------

Source	Activity	Fund Type	Budget ($1000s)	FTEs
		Total:	0.00	0.00

UNFUNDED --

	Activity	Fund Type	Budget ($1000s)	FTEs
Year x:	RES	One-time	20.00	0.2
		Grand Total:	20.00	0.2

(Optional) Alternative Actions/Solutions and Impacts

"No Action" could present three serious problems:

(i) Legal proceedings could evolve in the near future regarding water rights for the acequia (irrigation ditch) at Quarai and the park would be unprepared.

(ii) The long term provision of water for park use will be in question without this study being made, posing a serious impact upon park operations, development, and visitor use.

(iii) Division of the water also could potentially affect wetlands at Quarai, involving wetlands regulations confusion.

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: 516 DM2 APP. 2, 1.6

Project Statement SAPU-N-016.000 Priority 4

Title : **Hydrogeology Advice for the Water Supply Well at Abo**

Funding Status: Funded: 0.00 Unfunded: 5.00

Servicewide Issues : N11 (Water Qual-Ext)

Cultural Resource Type: N-

RMAP Program codes : 10-

238 Package Number :

Problem Statement

The Abo Unit of the Salinas Pueblo Missions National Monument has a shallow well which is not adequate as a public water supply and is now used only to operate the staff rest room. This water comes from a shallow aquifer and has exhibited a positive coliform count in past samples. Possibly contaminants from the nearby arroyo (which is affected by upstream grazing) or pollution from the rest room's cess pool are contaminating the shallow aquifer. At present, visitors only have outdoor toilets and bottled drinking water for their use.

The Public Health Service has recommended consistently that a new well should be installed at the Abo Unit. The 1997 Water Resources Management Plan for the monument agreed with the Public Health Service that an adequate well should be and could be developed. The geology of the area and the productivity and water quality of existing wells in the area indicate that well development is quite feasible.

Description of Recommended Project or Activity

The park needs financing to support drilling of a new well and support for a geologist to oversee this drilling so that it will be effective and successful.

Two major mainly-sandstone formations meet near the surface just at the AbO Unit, and the geology of the area is therefore especially complex. Some depths of the aquifers contain thin limestone layers that can yield good quality water, whereas other strata of the aquifers are high in gypsum content and yield a water too high in sulfur for human consumption.

The 1997 Water Resources Management Plan emphasized that in addition to financing the well drilling, a qualified hydrogeologist also must be on hand to monitor the well drilling process, to advise drillers on the appropriate strata for the best water yield and water quality. Based on wells in the surrounding area, the well depth would probably be somewhere between 200 and 400 feet. The hydrogeologist also could help advise on screening, pump size and other physical characteristics for the well and pump.

The water rights of the well will need to be confirmed with a request to the State Engineer Office prior to development of the new well.

BUDGET AND FTEs:

-------------------------FUNDED-----------------------------

Source Activity	Fund Type	Budget ($1000s)	FTEs
1995: RG-RM-NAT ADM	One-time	0.00	0.00

			Total:	0.00	0.00

-------------------------- UNFU NDED------------------------

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:	PRO	Recurring	5.0	0.1
		Grand Total:	5.0	0.1

(Optional) Alternative Actions/Solutions and Impacts

If this project is not supported, visitors at the Abe, Unit must continue to use outdoor toilets and drink bottled water.

Compliance codes : EXCL (CATEGORICAL EXCLUSION)

Explanation: The funding will provide for the geologist

APPENDIX B. PRINCIPAL WATER RESOURCE CONTACTS AND SOURCE S OF INFORMATION FOR SALINAS PUEBLO MISSION NATIONAL MONUMENT.

PERSON(S)	INFORMATION AND TELEPHONE
Chacon, Donnie	Manager for the Punta de Agua town water supply 505 847-2732
Cbola National Forest, Mountainair (the District)	Information on land use, vegetation, grazing, timber, vegetation. Frank Martinez (Ranger) and Jim Bates (Natural Resources). 505 847-2990
Cbola National Forest, Albuquerque (the Forest)	Some basic information on vegetation and erosion in the Manzanos. Dave Pawelek or Doug Shaw. 505 761-4650 x251.
Corps of Engineers, Albuquerque	Information on past flood plain work (Thomas Ryan, 505 342-3380) and sediment in the general area (Darrell Eidson, 342-3327). For information on wetlands: Jim Wood or Louis Clarke at 342-3281.
Deuser, Curtis, Lake Mead, NPS	National Park Service person with extensive experience on salt-cedar control (702) 293-8979. A Fish and Wildlife Service expert in New Mexico is John Taylor (Bosque del Apache) at (505) 835-1828.
Fleming, William, Santa Fe	Hydrologist, Consultant and with University of NM. Knows general hydrology of the area. 505 983-4845.
Gonzales, Tobia, Punta de Agua	Coordinator for the Punta de Agua irrigation ditch association. 505 847-2402
Lujan, David, Albuquerque	Tonantzin Land Institute. Special focus on water rights and "empowerment" for indigenous groups. 505 766-9938.
McWilliams, Steve, Santa Fe	Now with Santa Fe National Forest, but was with the Cbola, so has information on area. 505 988-6940.
NM Game and Fish, Santa Fe	Expertise on fisheries and aquatic biology. John Pittenger, Aquatic Biologist. 505 827-9907.
NM State Engineer Library, Santa Fe	Some key water references and consultant reports. Also has water rights files upstairs (Joseph Montoya). Librarian Barbara Austin. 505 827-6187.
NM Environment Department, State Surface Water Quality Bureau, Santa Fe	Can provide information and recent standards on water quality and pollutants Brian Wirtz, Program Manager 505 827-2470. For 401 certification: Cecilia Brown at 827-0106 or Sandra Maes at 827-0712.
NM Tech University, Socorro	Some water quality and geologic information on the area. Mike Whitworth (has data). 505 835-5921 or -5420.
NM State Library, Santa Fe, Santa Fe	Basic geologic reports and maps (Federal repository library). _ Librarian Peg Johnson (was once NPS person) can help. 827-3824.

PERSON(S)	INFORMATION AND TELEPHONE
NRCS, Albuquerque (State Office)	Some information on geology, sediment and geomorphology in the area. Kathy Woida, Geologist. 505 761-4450.
NRCS, Mountainair (District)	Natural Resources Conservation Service, local reference on soils and land use. Richard Spencer. 505 847-2941.
Schuller, Laurie, Albuquerque	Engineer with special interest in Quarai acequia history. 505 867-4886.
Shomaker Inc, Albuquerque	Preparing the Torrance County planning documents on water in 1996. Roger Perry. 505 345-3407.
US Geological Survey, Albuquerque	Can provide data on wells they monitor. Handling data: Linda Beal or Roy Cruz. 505 262-5339. Jerry Larson was a reviewer of this report. (Russell Livingston is head of the USGS in New Mexico).
Water Resources Division, NPS, Fort Collins	Water Rights: Chuck Pettee (970) 225-3505; EPA STORET data: Dean Tucker (970) 225-3516; Other technical questions: Bill Jackson (970) 225-3503.

A. 1 he maximum contaminant levels for inorganic contaminants specified in subsections A(1)-(2), A(4)-(8), A(10)-(16) of this Section apply to community water systems and non-transient, non-community water systems. The maximum contaminant levels specified in subsection A(3) and A(9) of this Section only apply to community water systems. The maximum contaminant levels specified in A(12)-(14) apply to community, non-transient non-community, and non-community water systems.

	Contaminant	MCL (mg/1)	MCL (µg/L)
1.	Antimony	0.006	6
2.	Asbestos	7 Million Fibers/liter (longer than 10 µm)	
3.	Arsenic	0.05	50
4.	Barium	2	2000
5.	Beryllium	0.004	4
6.	Cadmium	0.005	5
7.	Chromium	0.1	100
8.	Cyanide	0.2	200
9.	Fluoride	4.0	
10.	Mercury	0.002	2
11.	Nickel	0.1	100
12.	Nitrate (as N)	10	
13.	Nitrite (as N)	1	
14.	Total Nitrate and Nitrite (as N)	10	
15.	Selenium	0.05	50
16.	Thallium	0.002	2

203. MAXIMUM CONTAMINANT LEVELS FOR ORGANIC CONTAMINANTS.-

A. The following maximum contaminant levels for organic contaminants apply to community and non-transient, non-community water systems.

	Contaminant	MCL (mg/1)	MCL (/tg/L)
1.	Alachlor	0.002	2
2.	Atrazine	0.003	3
3.	Carbofuran	0.04	40
4.	Chlordane	0.002	2
5.	Dibromochloropropane	0.0002	0.2
6.	2,4-D	0.07	70
7.	Ethylene dibromide	0.00005	0.05
8.	Heptachlor	0.0004	0.4
9.	Heptachlor epoxide	0.0002	0.2
10.	Lindane	0.0002	0.2
11.	Methoxychlor	0.04	40
12.	Polychlorinated biphenyls	0.0005	0.5

13.	Pentachlorophenol	0.001	1
14.	Toxaphene	0.003	3
15.	2,4,5-TP	0.05	50
16.	Benzo[a]pyrene	0.0002	0.2
17.	Dalapon	0.2	200
18.	Di(2-ethylhexyl)adipate	0.4	400
19.	Di(2-ethylhexyl)phthalate	0.006	6
20.	Dinoseb	0.007	7
21.	Diquat	0.02	20
22.	Endothall	0.1	100
23.	Endrin	0.002	2
24.	Glyphosate	0.7	700
25.	Hexachlorobenzene	0.001	1
26.	Hexachlorocyclopentadiene	0.05	50
27.	Oxamyl (Vydate)	0.2	200
28.	Picloram	0.5	500
29.	Simazine	0.004	4
30.	2,3,7,8-TCDD (Dioxin)		.00003

B. The following maximum contaminant level applies only to community water systems which serve a population of 10,000 or more individuals and which add a disinfectant to the water in any part of the drinking water treatment process. Compliance with the maximum contaminant level for trihalomethanes is calculated pursuant to Section 313.

Contaminant	MCL (mg/1)
Total trihalomethanes	0.10

C. The following maximum contaminant levels for organic contaminants apply to community and non-transient, non-community water systems.

APPENDIX D – WATER QUALITY DATA FROM WHITWORTH

Table 1: Sample Q-1 Quarai water well, at Visitors Center

Collection Date: 6-15-94 Collected by: M. Whitworth and G., Fulfur

Location: SE 1/4 of the SE 1/4 of Section 3, T4N, R6E; Visitors Center at Quari Ruins, Salinas National Monument ..(Located9n Punta De Agua, New Mexico 7.5' U_S.G.S..Quadrangle),

Field pH: 7.85 Laboratory pH: 7.8

Field Conductivity: 355 .ltSlcm Laboratory Conductivity: 400 AS/cm

Total Dissolved Solids: 219 ppm Field Temperature 17.7°C

Charge BalanceErr.or: 032%

NMBMMR Laboratory Number: 0454

Analysis	Concentration (W^{m})	Analytical Uncertainty at 26 (PP^{m})	SDWA Limit (PP^{m})
Hardness (CaCO3)	184	± 2.7	250
Carbonate ($CO3^{—}$)	0	Not Applicable	350
Bicarbonate (HCO3-)	215	± 2.8	—
Chloride (Cl-)	8.9	± 1.3	250
Sulfate (SO_4)	18	± 0.9	
Nitrate (NO3-)	3	± 1.0	10
Fluoride (F-)	0.31	± 0.052	4
Sodium (Na^{+})	12	± 0.43	.200
Potassium (K+)	2.1	± 1.14	1000
Magnesium (Mg^{++})	10	± 0.28	125
Calcium .(Ca)	57	±1:4	200
Total Iron (Fe)	< 0.1	Not Applicable	—
Manganese (Mn)	< 0.1	Not Applicable	--
Nickel (Ni)	< 0.5	Not Applicable	—
Zinc (Zn)	< 0.02	Not Applicable	—

Note: --_means__the.parameter is notregi,lated der_the. Safe,Drinking Water Act.

Table 2: Sample Q-2; Surface Water (SE of Visitor's Center)

Collection Date: 6-15-94 Collected by: M. Whitworth and G. Fulfur

Location: SE 1/4 of the SE 1/4 of Section 3, T4N, R6E; Visitor's Center at Quari Ruins, Salinas National Monument (Located on Punta De Agua, New Mexico 7.5' IL &G.& G _ Quadrangle).

Field pH: 8.17 Laboratory pH: 7.7

Field Conductivity: 390 pS/cm Laboratory Conductivity: 400 41$/cm

Total Dissolved Solids: 263 ppm Field Temperature 20.3°C

Charge Balance Error: -1.34 % NMBMMR Laboratory Number:

0455

Analysis	Concentration (PP^m)	Analytical Uncertainty at 26 (PP^m)	SDWA Limit (PP^m)
Hardness (CaCO3)	226	± 3.34	250
Carbonate (CO3—)	0	Not Applicable	350
Bicarbonate ($HCO3^-$)	277	± 3.7	--
Chloride (Cr)	5	± 0.74	250
Sulfate (SO_4—)	22	± 1.08	--
Nitrate ($NO3^-$)	0.24	± 0.008	10
Fluoride (F-)	0.3	± 0.05	4
Sodium (Na^+)	11	± 0.39	200
Potassium (K^+)	1.1	± 0.6	1000
Magnesium (Mg^{-14})	8.8	± 0.25	125
Calcium ($-Ca^{-H'}$)	76	± 1.9	200
Total Iron (Fe)	< 0.1	Not Applicable	--
Manganese (Mn)	< 0.1	Not Applicable	—
Nickel (Ni)	< 0.5	Not Applicable	—
Zinc (Zn)	< 0.02	Not Applicable	—

Note: -- means the parameter is notregul&lunder the.______ Safe,Drinking Water Act

Table 3: Sample Q-3; Surface Water

Collection Date: 6-15-94 Collected by: M. Whitworth and G. Fulfur

Location: SW 1/4 of the SW 1/4 of Section 2, T4N, R6E; Visitor's Center at Quari Ruins, Salinas National Monument (Located Dn Punta De Agua, New Mexico 7.5' U S. G. S. Quadrangle).

Field pH: 8.68 Laboratory pH: 7.8

Field Conductivity: 4581,.tSLcm Laboratory Conductivity: 500 p S/cm

Total Dissolved Solids: 296 ppm Field Temperature 19.3°C

Charge BalanceError: -115 %

NMBMMR Laboratory Number: 0456

Analysis	Concentration (PP^m)	Analytical Uncertainty at 2 a (PP^m)	SDWA Limit (PP^m)
Hardness (CaCO3)	238	± 3.5	250
Carbonate ($CO3^{--}$)	0	Not Applicable	350
Bicarbonate (HCO3 -)	310	4.1	—
Chloride (Cr)	13	± 1.9	250
Sulfate (S O 4)	18	± 0.88	--
Nitrate ($NO3^{-}$)	< 0.2	Not Applicable	10
Fluoride (F^{-})	0.39	± 0.07	4
Sodium (Na^{+})	21	± 0.75	200
Potassium (K^{+})	1.4	± 0.76	1000
Magnesium .(Mg^{-H-})	13	± 0.37	125
Calcium (Ca^{m})	74	± 1.86	200
Total Iron (Fe)	< 0.1	Not Applicable	--
Manganese (Mn)	< 0.1	Not Applicable	—
Nickel (Ni)	< 0.5	Not Applicable	
Zinc (Zn)	< 0.02	Not Applicable	--

Note: -- means the _parameter is not ____________________________ Water .Act

Table 4: Sample A-1; Water well at Abo Visitor's Center.

Collection Date: 6-15-94 Collected by: M. Whitworth and G. Fulfur

Location: SE 1/4 of SW 1/4, Section 25, T3N, R5E; At Visitor's Center Abo Ruins. (Abo, N. Mex. U. S. G. S., 7_5'.quadrangle).

Field pH: 7.62 Laboratory pH: 7.5

Field Conductivity: 591~.tS/cm Laboratory Conductivity: 600 pS/cm

Total Dissolved Solids: 246 ppm Field Temperature 16.3°C Charge Balance

Error 0.83 %

NMBMMR Laboratory Number: 0451

Analysis	Concentration	Analytical Uncertainty at 2a	SDWA Limit (ppm)
Hardness (CaCO3)	190	± 2.8	250
Carbonate ($CO_3^{=}$)	0	Not Applicable	350
Bicarbonate (HCO_3^-)	223	± 2.9	—
Chloride (Cl^-)	9	± 1.3	250
Sulfate (S O 4)	40	± 1.96	--
Nitrate (NO_3^-)	1.2	± 0.04	10
Fluoride (F^-)	0.67	± 0.11	4
Sodium {Na^+)	24	± 0.85	200
Potassium (K^+)	1.3	± 0.71	1000
Magnesium (Mg^r)	28	± 0.79	125
Calcium (Ca^{++})	30	± 0.75	200
Total Iron (Fe)	< 0.1	Not Applicable	—
Manganese (Mn)	< 0.1	Not Applicable	—
Nickel (Ni)	< 0.50	Not Applicable	—
Zinc (Zn)	< 0.002	Not Applicable	—

Note: -- means the parameter is not regulated under the Safe Drinking Water Act

Table 5: Sample A-2; Surface water north of Abo Visitor's Center.

Collection Date, 6-15-94 Collected by: M. Whitworth and G. Fulfill

Location: NW 1/4 of SE 1/4, Section 25, T3N, R5E; In stream north of Visitor's Center at Abo Ruins. (Abo, N. Mex. U.. S. G S. 7.5' quadrangle).

Field pH: 8.68 Laboratory pH: 8.1

Field Conductivity: 419 4.IS/cm Laboratory Conductivity; 500 i..tSicm

Total Dissolved Solids: 292 ppm Field Temperature 26.5°C Charge

Ba1~noeErrol: 0 81 %

NMBMMR Laboratory Number: 0452

Analysis	Concentration (PPm)	Analytical Uncertainty at 2a (PPm)	SDWA Limit (PPm)
Hardness (CaCO3)	235	± 3.5	250
Carbonate (CO_3^{--})	0	Not Applicable	350
Bicarbonate {HCa3	287	± 3.8	
Chloride ($C1^-$)	7.4	± 1.1	250
Sulfate (SO4-')	36	± 1.76	
Nltr t (NO3-)	0.5	± 0.02	10
Fluoride (F-)	0.47	± 0.08	4
Sodium (Na^+)	24	± 0.85	200
Potassium (l()	1.7	± 0.92	1000
Magnesium (Mg^{++})	25	±0.70	125
Calcium{Ca^{++})	53	± 1.33	200
Total Iron (Fe)	< 0.1	Not Applicable	—
Manganese (Mn)	< 0.1	Not Applicable	—
Nickel (Ni)	< 0.50	Not Applicable	--
Zinc (Zn)	< 0.02	Not Applicable	—

Note: -- means the parameter is not regulated under the Safe Drinking Water Act

APPENDIX E —SOME WATER QUALITY DATA FROM STORET

ouarai Unit

Station Number	STORET ID #	Description	Station Type	Agency	Date Station Entered In System
Station: 0001	343405106172501	04N.06E.14.300	/TYPA/AMBNT/SPRING	112WRD	05/19/1979
Station: 0002	343533106173901	04N.06E.03.444	/TYPA/AMBNT/WELL	112WRD	07/21/1979
Station: 0003	343623106190601	04N.06E.04.211	/TYPA/AMBNT/WELL	112WRD	07/21/1979
Station: 0004	343715106175500	CANYON COLORADO AT HWY 10	/TYPA/AMBNT/STREAM	112WRD	11/18/1975
Station: 0005	343758106162001	04N.06E.26.242	/TYPA/AMBNT/WELL	112WRD	07/21/1979
Station: 0006	343838106203500	CANON PINOS REALES AT MANZANO,NM	/TYPA/AMBNT/STREAM	112WRD	08/30/1976
Station: 0007	343845106204601	MANZANO GRANT	/TYPA/AMBNT/SPRING	112WRD	02/28/1978
Station: 0008	343855106203700	CANON DE BARTOLO AT MANZANO,NM	/TYPA/AMBNT/STREAM	112WRD	11/18/1975
Station: 0009	344003106175301	05N.06E.10.344A	/TYPA/AMBNT/WELL	112WRD	07/21/1979

Abo Unit

Station Number	STORET ID #	Description	Station Type	Agency	Date Station Entered In System
Station: 0001	342307106260301	02N.05E.20.244	/TYPA/AMBNT/WELL	112WRD	05/19/1979
Station: 0002	342447106190701	02N.06E.09.233	/TYPA/AMBNT/WELL	112WRD	07/21/1979
Station: 0003	342530106271001	02N.05E.06.224	/TYPA/AMBNT/WELL	112WRD	05/19/1979
Station: 0004	342611106180601	03N.06E.34.431	/TYPA/AMBNT/WELL	112WRD	07/21/1979
Station: 0005	342634106263001	03N.05E.32.210	/TYPA/AMBNT/WELL	112WRD	07/21/1979
Station: 0006	342715106252001	03N.05E.28.440	/TYPA/AMBNT/WELL	112WRD	07/21/1979
Station: 0007	342724106195401	03N.06E.29.243	/TYPA/AMBNT/WELL	112WRD	07/21/1979

Gran Quivira Unit

Station Number	STORET ID #	Description	Station Type	Agency	Date Station Entered In System
Station: 0001	341220106062501	01S.08E.21.431	/TYPA/AMBNT/WELL	112WRD	05/19/1979
Station: 0002	341356106080801	01S.08E.07.322	/TYPA/AMBNT/WELI.	112WRD	05/19/1979
Station: 0003	341413106042201	01S.08E.11.322	/TYPA/AMBNT/WELL	112WRD	05/19/1979
Station: 0004	341413106064701	01S.08E.09.310	/TYPA/AMBNT/WELL	112WRD	05/19/1979
Station: 0005	341448106031501	01S.08E.01.433	/TYPA/AMBNT/WELL	112WRD	05/19/1979
Station: 0006	341500106070001	"NO INFORMATION IN THE STATION HEADER FILE."	/TYPA/AMBNT/WELL	112WRD	11/06/1982
Station: 0007	341502106064001	01S.08E.04.323	/TYPA/AMBNT/WELL	112WRD	05/19/1979
Station: 0008	341525106051001	01S.08E.03.214	/TYPA/AMBNT/WELL	112WRD	05/19/1979
Station: 0009	341559106061801	01N.08E.33.421	/TYPA/AMBNT/WELL	112WRD	07/21/1979
Station: 0010	341616106061801	01N.08E.33.210	/TYPA/AMBNT/WELL	112WRD	07/21/1979
Station: 0011	341638106111801	01N.07E.26.331	/TYPA/AMBNT/WELL	112WRD	07/21/1979

*** Station: 0001 ***.

341220106062501
34 12 20.0 106 06 25.0 2
018.08E.21.431
35053 NEW MEXICO SOCORRO

STORET RETRIEVAL FOR
GRAN QUIVIRA UNIT OF
SALINAS PUEBLO N.M.
8/21/96

/TYPA/AMBNT/WELL

112WRD 790519 13050003
0000 FEET DEPTH

PARAMETER	MEDIUM	RMK	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00095 CNDUCTVY AT 25C MICROMHO		1	2350.000			2350	2350	50/08/02	50/08/02
00410 T ALK CACO3 MG/L		1	131.0000			131	131	50/08/02	50/08/02
00440 HCO3 ION HCO3 MG/L		1	160.0000			160	160	50/08/02	50/08/02
00445 CO3 ION CO3 MG/L		1	.0000000			0	0	50/08/02	50/08/02
00618 NO3-N DISS MG/L		1	.3400000			.34	.34	50/08/02	50/08/02
00900 TOT HARD CACO3 MG/L		1	1600.000			1600	1600	50/08/02	50/08/02
00902 NC HARD CACO3 MG/L		1	1500.000			1500	1500	50/08/02	50/08/02
00915 CALCIUM CA,DISS MG/L		1	480.0000			480.0	480.0	50/08/02	50/08/02
00925 MGNSIUM MG,DISS MG/L		1	110.0000			110.0	110.0	50/08/02	50/08/02
00933 NA+K MG/L		1	2.000000			2.00	2.00	50/08/02	50/08/02
00940 CHLORIDE TOTAL MG/L		1	34.00000			34	34	50/08/02	50/08/02
00945 SULFATE SO4-TOT MG/L		1	1400.000			1400	1400	50/08/02	50/08/02
00950 FLUORIDE F,DISS MG/L		1	.8000000			.80	.80	50/08/02	50/08/02
00955 SILICA DISOLVED MG/L		1	19.00000			19.0	19.0	50/08/02	50/08/02
70301 DISS SOL SUM MG/L		1	2120.000			2120	2120	50/08/02	50/08/02
70303 DISS SOL TONS PER ACRE-FT		1	2.880000			2.88	2.88	50/08/02	50/08/02
71851 NITRATE DISS-NO3 MG/L		1	1.500000			1.5	1.5	50/08/02	50/08/02
72019 DEPTH-FT BL LAND SURFACE		1	650.0000			650.00	650.00	50/08/02	50/08/02
84000 GEOLOGIC AGE CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	50/08/02	50/08/02
84001 AQUIFER NAME CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	50/08/02	50/08/02

*** Station: 0002 ***

341356106080801
34 13 56.0 106 08 08.0 2
01S.08E-07.322
35053 NEW MEXICO SOCORRO

STORET RETRIEVAL FOR
GRAN QUIVIRA UNIT OF
SALINAS PUEBLO N.M.
8/21/96

/TYPA/AMBNT/WELL

112WRD 790519 13050003
0000 FEET DEPTH

PARAMETER	MEDIUM	RMK	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00095 CNDUCTVY AT 25C MICROMHO		1	2150.000			2150	2150	57/06/08	57/06/08
00400 PH SU		1	7.300000			7.30	7.30	57/06/08	57/06/08
00405 CO2 MG/L		1	16.00000			16.0	16.0	57/06/08	57/06/08
00410 T ALK CACO3 MG/L		1	164.0000			164	164	57/06/08	57/06/08
00440 HCO3 ION HCO3 MG/L		1	200.0000			200	200	57/06/08	57/06/08
00445 CO3 ION CO3 MG/L		1	.0000000			0	0	57/06/08	57/06/08
00618 NO3-N DISS MG/L		1	.4500000			.45	.45	57/06/08	57/06/08
00900 TOT HARD CACO3 MG/L		1	1500.000			1500	1500	57/06/08	57/06/08
00902 NC HARD CACO3 MG/L		1	1300.000			1300	1300	57/06/08	57/06/08
00915 CALCIUM CA,DISS MG/L		1	400.0000			400.0	400.0	57/06/08	57/06/08
00925 MGNSIUM MG,DISS MG/L		1	110.0000			110.0	110.0	57/06/08	57/06/08
00933 NA+K MG/L		1	8.000000			8.00	8.00	57/06/08	57/06/08
00940 CHLORIDE TOTAL MG/L		1	35.00000			35	35	57/06/08	57/06/08
00945 SULFATE SO4-TOT MG/L		1	1200.000			1200	1200	57/06/08	57/06/08
00950 FLUORIDE F,DISS MG/L		1	.6000000			.60	.60	57/06/08	57/06/08
70301 DISS SOL SUM MG/L		1	1880.000			1880	1880	57/06/08	57/06/08
70303 DISS SOL TONS PER ACRE-FT		1	2.560000			2.56	2.56	57/06/08	57/06/08
71851 NITRATE DISS-NO3 MG/L		1	2.000000			2.0	2.0	57/06/08	57/06/08
72008 TOT DPTH OF WELL FT		1	500.0000			500.0	500.0	57/06/08	57/06/08
72019 DEPTH-FT BL LAND SURFACE		1	480.0000			480.00	480.00	57/06/08	57/06/08
84000 GEOLOGIC AGE CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	57/06/08	57/06/08
84001 AQUIFER NAME CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	57/06/08	57/06/08

** Station: 0001 **

342307106260301
34 23 07.0 106 26 03.0 2
02N.05E.20.244
35053 NEW MEXICO
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STORET RETRIEVAL FOR
ABO UNIT OF
SALINAS PUEBLO N.M.
8/21/96

/TYPA/AMBNT/WELL

112WRD 790519 13020203
0000 FEET DEPTH

PARAMETER	MEDIUM	RMK	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010 WATER TEMP CENT		1	14.00000			14.0	14.0	49/12/19	49/12/19
00095 CNDUCTVY AT 25C MICROMHO		1	3010.000			3010	3010	49/12/19	49/12/19
00410 T ALK CACO3 MG/L		1	148.0000			148	148	49/12/19	49/12/19
00440 HCO3 ION HCO3 MG/L		1	180.0000			180	180	49/12/19	49/12/19
00445 CO3 ION CO3 MG/L		1	.0000000			0	0	49/12/19	49/12/19
00618 NO3-N DISS MG/L		1	5.900000			5.90	5.90	49/12/19	49/12/19
00900 TOT HARD CACO3 MG/L		1	1900.000			1900	1900	49/12/19	49/12/19
00902 NC HARD CACO3 MG/L		1	1800.000			1800	1800	49/12/19	49/12/19
00915 CALCIUM CA,DISS MG/L		1	470.0000			470.0	470.0	49/12/19	49/12/19
00925 MGNSIUM MG,DISS MG/L		1	180.0000			180.0	180.0	49/12/19	49/12/19
00933 NA+K MG/L		1	98.00000			98.00	98.00	49/12/19	49/12/19
00940 CHLORIDE TOTAL MG/L		1	48.00000			48	48	49/12/19	49/12/19
00945 SULFATE SO4-TOT MG/L		1	1800.000			1800	1800	49/12/19	49/12/19
70301 DISS SOL SUM MG/L		1	2740.000			2740	2740	49/12/19	49/12/19
70303 DISS SOL TONS PER ACRE-FT		1	3.730000			3.73	3.73	49/12/19	49/12/19
71851 NITRATE DISS-NO3 MG/L		1	26.00000			26.0	26.0	49/12/19	49/12/19
84000 GEOLOGIC AGE CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	49/12/19	49/12/19
84001 AQUIFER NAME CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	49/12/19	49/12/19

**********************•e******************************** Station: 0002 **

342447106190701
34 24 47.0 106 19 07.0 2
02N.06E.09.233
35057 NEW MEXICO TORRANCE

STORET RETRIEVAL FOR
ABO UNIT OF
SALINAS PUEBLO N.M.
8/21/96

/TYPA/AMBNT/WELL

112WRD 790721 13020203
0000 FEET DEPTH

PARAMETER	MEDIUM	RMK	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00095 CNDUCTVY AT 25C MICROMHO		1	2840.000			2840	2840	50/08/00	50/08/00
00410 T ALK CACO3 MG/L		1	156.0000			156	156	50/08/00	50/08/00
00440 HCO3 ION HCO3 MG/L		1	190.0000			190	190	50/08/00	50/08/00
00445 CO3 ION CO3 MG/L		1	.0000000			0	0	50/08/00	50/08/00
00618 NO3-N DISS MG/L		1	6.800000			6.80	6.80	50/08/00	50/08/00
00900 TOT HARD CACO3 MG/L		1	2000.000			2000	2000	50/08/00	50/08/00
00902 NC HARD CACO3 MG/L		1	1900.000			1900	1900	50/08/00	50/08/00
00915 CALCIUM CA,DISS MG/L		1	590.0000			590.0	590.0	50/08/00	50/08/00
00925 MGNSIUM MG,DISS MG/L		1	140.0000			140.0	140.0	50/08/00	50/08/00
00933 NA+K MG/L		1	26.00000			26.00	26.00	50/08/00	50/08/00
00940 CHLORIDE TOTAL MG/L		1	25.00000			25	25	50/08/00	50/08/00
00945 SULFATE SO4-TOT MG/L		1	1800.000			1800	1800	50/08/00	50/08/00
00950 FLUORIDE F,DISS MG/L		1	.5000000			.50	.50	50/08/00	50/08/00
00955 SILICA DISOLVED MG/L		1	26.00000			26.0	26.0	50/08/00	50/08/00
70301 DISS SOL SUM MG/L		1	2710.000			2710	2710	50/08/00	50/08/00
70303 DISS SOL TONS PER ACRE-FT		1	3.690000			3.69	3.69	50/08/00	50/08/00
71851 NITRATE DISS-NO3 MG/L		1	30.00000			30.0	30.0	50/08/00	50/08/00
72019 DEPTH-FT BL LAND SURFACE		1	8.000000			8.00	8.00	50/08/00	50/08/00
84000 GEOLOGIC AGE CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	50/08/00	50/08/00
84001 AQUIFER NAME LODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	50/08/00	50/08/00

** Station: **0003** **

342530106271001
34 25 30.0 106 27 10.0 2
02N.05E.06.224
35053 NEW MEXICO SOCORRO

STORET RETRIEVAL FOR
ABO UNIT OF
SALINAS PUEBLO N.M.
8/21/96

/TYPA/AMBNT/WELL

112WRD 790519 13020203
0000 FEET DEPTH

PARAMETER				MEDIUM	RMK	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010	WATER	TEMP	CENT		1	14.50000			14.5	14.5	49/12/08	49/12/08
00095	CMDUCTVY	AT 25C	MICROMHO		1	2060.000			2060	2060	49/12/08	49/12/08
00410	T ALK	CACO3	MG/L		1	459.0000			459	459	49/12/08	49/12/08
00440	HCO3 ION	HCO3	MG/L		1	560.0000			560	560	49/12/08	49/12/08
00445	CO3 ION	CO3	MG/L		1	.0000000			0	0	49/12/08	49/12/08
00618	NO3-N	DISS	MG/L		1	.1600000			.16	.16	49/12/08	49/12/08
00900	TOT HARD	CACO3	MG/L		1	46.00000			46	46	49/12/08	49/12/08
00902	NC HARD	CACO3	MG/L		1	.0000000			0	0	49/12/08	49/12/08
00915	CALCIUM	CA,DISS	MG/L		1	6.800000			6.8	6.8	49/12/08	49/12/08
00925	MGNSIUM	MG,DISS	MG/L		1	7.000000			7.0	7.0	49/12/08	49/12/08
00933	NA+K		MG/L		1	470.0000			470.00	470.00	49/12/08	49/12/08
00940	CHLORIDE	TOTAL	MG/L		1	64.00000			64	64	49/12/08	49/12/08
00945	SULFATE	SO4-TOT	MG/L		1	500.0000			500	500	49/12/08	49/12/08
70301	DISS SOL	SUM	MG/L		1	1330.000			1330	1330	49/12/08	49/12/08
70303	DISS SOL TONS PER ACRE-FT				1	1.810000			1.81	1.81	49/12/08	49/12/08
71851	NITRATE	DISS-NO3	MG/L		1	.7000000			.7	.7	49/12/08	49/12/08

** Station: **0004** **

342611106180601
34 26 11.0 106 18 06.0 2
03N.06E.34.431
35057 NEW MEXICO TORRANCE

STORET RETRIEVAL FOR
ABO UNIT OF
SALINAS PUEBLO N.M.
8/21/96

/TYPA/AMBNT/WELL

112WRD 790721 13020203
0000 FEET DEPTH

PARAMETER				MEDIUM	RMK	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00095	CNDUCTVY	AT 25C	MICROMHO		1	2530.000			2530	2530	50/08/10	50/08/10
00410	T ALK	CACO3	MG/L		1	98.00000			98	98	50/08/10	50/08/10
00440	HCO3 ION	HCO3	MG/L		1	120.0000			120	120	50/08/10	50/08/10
00445	CO3 ION	CO3	MG/L		1	.0000000			0	0	50/08/10	50/08/10
00618	NO3-N	DISS	MG/L		1	3.200000			3.20	3.20	50/08/10	50/08/10
00900	TOT HARD	CACO3	MG/L		1	1900.000			1900	1900	50/08/10	50/08/10
00902	NC HARD	CACO3	MG/L		1	1800.000			1800	1800	50/08/10	50/08/10
00915	CALCIUM	CA,DISS	MG/L		1	590.0000			590.0	590.0	50/08/10	50/08/10
00925	MGNSIUM	MG,DISS	MG/L		1	92.00000			92.0	92.0	50/08/10	50/08/10
00930	SODIUM	NA,DISS	MG/L		1	8.600000			8.60	8.60	50/08/10	50/08/10
00931	SODIUM	ADSBTION	RATIO		1	.1000000			.1	.1	50/08/10	50/08/10
00940	CHLORIDE	TOTAL	MG/L		1	10.00000			10	10	50/08/10	50/08/10
00945	SULFATE	$04-TOT	MG/L		1	1600.000			1600	1600	50/08/10	50/08/10
00950	FLUORIDE	F,DISS	MG/L		1	.4000000			.40	.40	50/08/10	50/08/10
00955	SILICA	DISOLVED	MG/L		1	21.00000			21.0	21.0	50/08/10	50/08/10
70301	DISS SOL	SUM	MG/L		1	2440.000			2440	2440	50/08/10	50/08/10
70303	DISS SOL TONS PER ACRE-FT				1	3.320000			3.32	3.32	50/08/10	50/08/10
71851	NITRATE	DISS-NO3	MG/L		1	14.00000			14.0	14.0	50/08/10	50/08/10
72019	DEPTH-FT BL LAND		SURFACE		1	11.00000			11.00	11.00	50/08/10	50/08/10
84000	GEOLOGIC	AGE	CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	50/08/10	50/08/10
84001	AQUIFER	NAME	CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	50/08/10	50/08/10

******************************* Station:0003
****** ******

343623106190601
34 36 23.0 106 19 06.0 2
04N.06E.04.211
35057 NEW MEXICO TORRANCE

STORET RETRIEVAL FOR
OUARAI UNIT OF
SALINA PUEBLO N.M.
8/21/96

/TYPA/AMBNT/WELL

112WRD 790721 13050001
0000 **FEET** DEPTH

PARAMETER		MEDIUM	RMK	NUMBE	**MEAN**	**VARIANCE**	**STAN DEV**	**MAXIMUM**	**MINIMU**	**BEG DATE**	END DATE
00095 CNDUCTVYAT 25C	MICROMNO				1			**475**	475	50/08/11	50/08/11
00410 T ALK CACO3	MG/L				1			238	238	50/08/11	50/08/11
00440 **HCO3** ION **HCO3**	MG/L				1			**290**	**290**	50/08/11	50/08/11
00445 CO3 ION CO3	MG/L				1			0	0	50/08/11	50/08/11
00618 NO3-N DISS	MG/L				1			1.30	1.30	50/08/11	50/08/11
00900 TOT HARDCACO3	MG/L				1			250	**250**	50/08/11	50/08/11
00902 NC HARDCACO3	MG/L				1			12	12	50/08/11	50/08/11
00915 CALCIUMCA,DISS	MG/L				1			77.0	77.0	50/08/11	50/08/11
00925 MGNSIUMMG,DISS	MG/L				1			13.0	13.0	50/08/11	50/08/11
00933 NA+K	MG/l				1			**6.70**	6.70	50/08/11	50/08/11
00940 CHLORIDE TOTAL	MG/L				1			6	6	50/08/11	50/08/11
00945 SULFATESO4-TOT	MG/L				1			11	11	50/08/11	50/08/11
00950 FLUORIDEF,DISS	MG/L				1			.20	.20	50/08/11	50/08/11
00955 SILICADISOLVED	MG/L				1			19.0	**19.0**	50/08/11	50/08/11
70301 DISS SOL SUM	MG/L				1			**280**	**280**	50/08/11	50/08/11
70303 DISS SOLTONS PER	ACRE-				1			.38	**.38**	50/08/11	50/08/11
71851 NITRATE DISS-NO3	MG/L				1			**5.9**	**5.9**	50/08/11	50/08/11
72019 DEPTH-FTBL LAND	SURFAC				1			18.00	18.00	50/08/11	50/08/11
84000 GEOLOGIC **AGE**	CODE		TXT	1	TEXT	TEXT	**TEXT**	TEXT	TEXT	50/08/11	50/08/11
84001 AQUIFER NAME	CODE		TXT	1	TEXT	TEXT	TEXT	TEXT	**TEXT**	50/08/11	50/08/11

***** ***** ********** **Station:**0006 ****************** ****** ******

343838106203500
34 38 38.0 106 20 35.0 2
CANON PINOS **REALES** AT MAN2ANO,NM
35057 NEW MEXICO TORRANCE

STORET RETRIEVAL FOR
OUARAI UNIT OF
SALINA PUEBLO N.M.
8/21/96

/TYPA/AMBNT/STREAM

112WRD 760830 13050001
0000 FEET DEPTH

PARAMETER		MEDIUM	RMK	**NUMBER**	**MEAN**	**VARIANCE**	**STAN DEV**	**MAXIMUM**	**MINIMUM**	**BEG DATE**	**END**
00010 WATER **TEMP**	CENT			1	15.00000			15.0	15.0	73/06/15	73/06/15
00061 STREAM FLOW,	**INST-CFS**			1	2.500000			3	3	73/06/15	73/06/15
00095 CNDUCTVY AT 25C	MICROMHO			1	**554.0000**			**554**	**554**	73/06/15	73/06/15
00400 PH	**SU**			1	7.700000			7.70	7.70	**73/06/15**	73/06/15
00405 CO2	MG/L			1	10.00000			10.0	10.0	73/06/15	73/06/15
00410 T ALK CACO3	MG/L			1	267.0000			267	267	73/06/15	73/06/15
00440 HCO3 ION HCO3	MG/L			1	326.0000			326	326	**73/06/15**	73/06/15
00445 CO3 ION CO3	MG/L			1	.0000000			0	0	73/06/15	73/06/15
00631 NO28NO3 N-DISS	MG/L			1	.0200000			.02	**.02**	**73/06/15**	73/06/15
00660 08780804 **PO4**	MG/L			1	.0300000			.03	.03	**73/06/15**	73/06/15
00671 **PHOS-DIS ORTHO**	MG/L			1	**.0100000**			.010	.010	73/06/15	73/06/15
00900 TOT **HARD** CACO3	MG/L			1	**280.0000**			**280**	**280**	**73/06/15**	73/06/15
00902 NC HARD **CACO3**	MG/L			1	13.00000			13	13	73/06/15	73/06/15
00915 CALCIUM **CA,DISS**	MG/L			1	98.00000			**98.0**	**98.0**	73/06/15	73/06/15
00925 **MGNSIUM MG,DISS**	MG/L			1	8.600000			**8.6**	**8.6**	73/06/15	73/06/15
00930 **SODIUM** NA,DISS	MG/L			1	7.600000			7.60	7.60	73/06/15	73/06/15
00931 SODIUM ADS8TION	RATIO			1	.2000000			.2	**.2**	73/06/15	73/06/15
00932 SODIUM	%			1	6.000000			6	6	73/06/15	73/06/15
00935 **PTSSIUM** K,DISS	MG/L			1	**.6000000**			**.60**	**.60**	73/06/15	73/06/15
00940 CHLORIDE TOTAL	MG/L			1	6.000000			**6**	**6**	73/06/15	73/06/15
00945 SULFATE SO4-TOT	MG/L			1	35.00000			**35**	**35**	**73/06/15**	73/06/15
00950 FLUORIDE **F,DISS**	MG/L			1	.4000000			**.40**	**.40**	73/06/15	73/06/15
00955 SILICA DISOLVED	MG/L			1	14.00000			14.0	14.0	73/06/15	73/06/15
01020 B,DISS	**UG/l**			1	**20.00000**			20	**20**	73/06/15	73/06/15
01046 IRON **FE,DISS**	UG/L			1	**70.00000**			70	70	**73/06/15**	73/06/15
70300 RESIDUE DISS-180 C	MG/L			1	307.0000			307	307	73/06/15	73/06/15
70301 DISS SOL SUM	MG/L			1	331.0000			331	331	73/06/15	73/06/15
70302 DISS SOL TONS/DA				1	2.070000			2.07	2.07	73/06/15	73/06/15
70303 DISS SOL TONS PER	ACRE-			1	.4200000			.42	.42	73/06/15	73/06/15
84000 GEOLOGIC AGE	CODE		TXT	1	**TEXT**	TEXT	**TEXT**	**TEXT**	TEXT	73/06/15	73/06/15
84001 **AQUIFER** NAME	**CODE**		TXT	1	**TEXT**	TEXT	TEXT	**TEXT**	TEXT	73/06/15	73/06/15

••• Station: 0005 ••

342634106263001
34 26 34.0 106 26 30.0 2
03N.05E.32.210
35061 NEW MEXICO VALENCIA

STORET RETRIEVAL FOR
ABO UNIT OF
SALINAS PUEBLO N.M.
8/21/96

/TYPA/AMBNT/WELL

112WRD 790721 13020203
0000 FEET DEPTH

PARAMETER	MEDIUM	RMK	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00095 CNDUCTVY AT 25C MICROMHO		1	1140.000			1140	1140	49/08/29	49/08/29
00410 T ALK CACO3 MG/l		1	279.0000			279	279	49/08/29	49/08/29
00440 HCO3 ION HCO3 MG/L		1	340.0000			340	340	49/08/29	49/08/29
00445 CO3 ION CO3 MG/L		1	42.00000			42	42	49/08/29	49/08/29
00618 NO3-N DISS MG/L		1	.0200000			.02	.02	49/08/29	49/08/29
00900 TOT HARD CACO3 MG/L		1	19.00000			19	19	49/08/29	49/08/29
00902 NC HARD CACO3 MG/L		1	.0000000			0	0	49/08/29	49/08/29
00915 CALCIUM CA,DISS MG/L		1	4.000000			4.0	4.0	49/08/29	49/08/29
00925 MGNSIUM MG,DISS MG/L		1	2.200000			2.2	2.2	49/08/29	49/08/29
00933 NA+K MG/L		1	260.0000			260.00	260.00	49/08/29	49/08/29
00940 CHLORIDE TOTAL MG/L		1	120.0000			120	120	49/08/29	49/08/29
00945 SULFATE SO4-TOT MG/l		1	70.00000			70	70	49/08/29	49/08/29
00950 FLUORIDE F,DISS MG/L		1	1.800000			1.80	1.80	49/08/29	49/08/29
00955 SILICA DISOLVED MG/L		1	13.00000			13.0	13.0	49/08/29	49/08/29
70301 DISS SOL SUM MG/L		1	683.0000			683	683	49/08/29	49/08/29
70303 DISS SOL TONS PER ACRE-FT		1	.9300000			.93	.93	49/08/29	49/08/29
71851 NITRATE DISS-NO3 MG/L		1	.1000000			.1	.1	49/08/29	49/08/29
72008 TOT DPTH OF WELL FT		1	25.00000			25.0	25.0	49/08/29	49/08/29

** Station: 0006 **

342715106252001
34 27 15.0 106 25 20.0 2
03N.05E.28.440
35061 NEW MEXICO

STORET RETRIEVAL FOR
ABO UNIT OF
SALINAS PUEBLO N.M.
8/21/96

/TYPA/AMBNT/WELL
VALENCIA

112WRD 790721 0000 FEET DEPTH

PARAMETER	MEDIUM	RMK	NUMBER	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00095 CNDUCTVY AT 25C MICROMHO			1	611.0000			611	611	49/08/29	49/08/29
00410 T ALK CACO3 MG/L			1	221.0000			221	221	49/08/29	49/08/29
00440 HCO3 ION HCO3 MG/L			1	270.0000			270	270	49/08/29	49/08/29
00445 CO3 ION CO3 MG/L			1	.0000000			0	0	49/08/29	49/08/29
00618 NO3-N DISS MG/L			1	1.700000			1.70	1.70	49/08/29	49/08/29
00900 TOT HARD CACO3 MG/L			1	180.0000			180	180	49/08/29	49/08/29
00902 NC HARD CACO3 MG/L			1	.0000000			0	0	49/08/29	49/08/29
00915 CALCIUM CA,DISS MG/L			1	32.00000			32.0	32.0	49/08/29	49/08/29
00925 MGNSIUM MG,DISS MG/L			1	25.00000			25.0	25.0	49/08/29	49/08/29
00933 NA+K MG/L			1	66.00000			66.00	66.00	49/08/29	49/08/29
00940 CHLORIDE TOTAL MG/L			1	27.00000			27	27	49/08/29	49/08/29
00945 SULFATE SO4-TOT MG/L			1	55.00000			55	55	49/08/29	49/08/29
00950 FLUORIDE F,DISS MG/L			1	1.000000			1.00	1.00	49/08/29	49/08/29
00955 SILICA DISOLVED MG/L			1	16.00000			16.0	16.0	49/08/29	49/08/29
70301 DISS SOL SUM MG/L			1	364.0000			364	364	49/08/29	49/08/29
70303 DISS SOL TONS PER ACRE-FT			1	.5000000			.50	.50	49/08/29	49/08/29
71851 NITRATE DISS-NO3 MG/L			1	7.600000			7.6	7.6	49/08/29	49/08/29
72008 TOT DPTH OF WELL FT			1	21.00000			21.0	21.0	49/08/29	49/08/29
84000 GEOLOGIC AGE CODE		TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	49/08/29	49/08/29
84001 AQUIFER NAME CODE		TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	49/08/29	49/08/29

*** Station: 0008 •*************** ***********************»*************

343855106203700
34 38 55.0 106 20 37.0 2
CANON DE BARTOLO AT MANZANO,NM
35057 NEW MEXICO TORRANCE

STORET RETRIEVAL FOR
OUARAI UNIT OF
SALINA PUEBLO N.M.
8/21/96

/TYPA/AMBNT/STREAM

112WRD 751118 13050001
0000 FEET DEPTH

PARAMETER	MEDIUM	RMK	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00010 WATER TEMP CENT		1	25.00000			25.0	25.0	73/06/15	73/06/15
00061 STREAM FLOW, INST-CFS		1	.8000000			.8	.8	73/06/15	73/06/15
00095 CNDUCTVY AT 25C MICROMHO		1	465.0000			465	465	73/06/15	73/06/15
00400 PH SU		1	7.900000			7.90	7.90	73/06/15	73/06/15
00405 CO2 MG/L		1	4.900000			4.9	4.9	73/06/15	73/06/15
00410 T ALK CACO3 MG/L		1	199.3100			199	199	73/06/15	73/06/15
00440 HCO3 ION HCO3 MG/L		1	243.0000			243	243	73/06/15	73/06/15
00445 CO3 ION CO3 MG/L		1	.0000000			0	0	73/06/15	73/06/15
00631 NO2&NO3 N-DISS MG/L		1	.1000000			.1	.1	73/06/15	73/06/15
00660 ORTHOPO4 PO4 MG/L		1	.0300000			.03	.03	73/06/15	73/06/15
00671 PHOS-DIS ORTHO MG/L P		1	.0100000			.010	.010	73/06/15	73/06/15
00900 TOT HARD CACO3 MG/L		1	230.0000			230	230	73/06/15	73/06/15
00902 NC HARD CACO3 MG/L		1	28.00000			28	28	73/06/15	73/06/15
00915 CALCIUM CA,DISS MG/L		1	75.00000			75.0	75.0	73/06/15	73/06/15
00925 MGNSIUM MG,DISS MG/L		1	9.800000			9.8	9.8	73/06/15	73/06/15
00930 SODIUM NA,DISS MG/L		1	9.500000			9.50	9.50	73/06/15	73/06/15
00931 SODIUM ADSBTION RATIO		1	.3000000			.3	.3	73/06/15	73/06/15
00932 PERCENT SODIUM %		1	8.000000			8	8	73/06/15	73/06/15
00935 PTSSIUM K,DISS MG/L		1	.8000000			.80	.80	73/06/15	73/06/15
00940 CHLORIDE TOTAL MG/0		1	7.700000			8	B	73/06/15	73/06/15
00945 SULFATE SO4-TOT MG/L		1	41.00000			41	41	73/06/15	73/06/15
00950 FLUORIDE F,DISS MG/L		1	.2000000			.20	.20	73/06/15	73/06/15
00955 SILICA DISOLVED MG/L		1	16.00000			16.0	16.0	73/06/15	73/06/15
01020 BORON B,DISS UG/L		1	20.00000			20	20	73/06/15	73/06/15
01046 IRON FE,DISS UG/L		1	9.000000			9	9	73/06/15	73/06/15
70300 RESIDUE DISS-180C MG/L		1	284.0000			284	284	73/06/15	73/06/15
70301 DISS SOL SUM MG/I		1	280.0000			280	280	73/06/15	73/06/15
70302 DIES SOL TONS/DAY		1	.6100000			.61	.61	73/06/15	73/06/15
70303 DISS SOL TONS PER ACRE-FT		1	.3900000			.39	.39	73/06/15	73/06/15

*** Station: 0009 ***

344003106175301
34 40 03.0 106 17 53.0 2
05N.06E.10.344A
35057 NEW MEXICO TORRANC
E

STORET RETRIEVAL FOR
OUARAI UNIT OF
SALINA PUEBLO N.M.
8/21/96

/TYPA/AMBNT/WELL

112WRD 790721 13050001
0000 FEET DEPTH

PARAMETER	MEDIUM	RMK	MEAN	VARIANCE	STAN DEV	MAXIMUM	MINIMUM	BEG DATE	END DATE
00059 FLOW RATE INST-GPM		1	4.000000			4.00	4.00	51/03/02	51/03/02
00095 CNDUCTVY AT 25C MICROMHO		1	634.0000			634	634	51/03/02	51/03/02
00410 T ALK CACO3 MG/L		1	287.0000			287	287	51/03/02	51/03/02
00440 HCO3 ION HCO3 MG/L		1	350.0000			350	350	51/03/02	51/03/02
00445 CO3 ION CO3 MG/L		1	18.00000			18	18	51/03/02	51/03/02
00618 NO3-N DISS MG/L		1	.0900000			.09	.09	51/03/02	51/03/02
00900 TOT HARD CACO3 MG/L		1	20.00000			20	20	51/03/02	51/03/02
00902 NC HARD CACO3 MG/0		1	.0000000			0	0	51/03/02	51/03/02
00915 CALCIUM CA,DISS MG/L		1	5.000000			5.0	5.0	51/03/02	51/03/02
00925 MGNSIUM MG,DISS MG/0		1	1.700000			1.7	1.7	51/03/02	51/03/02
00933 NA+K MG/L		1	150.0000			150.00	150.00	51/03/02	51/03/02
00940 CHLORIDE TOTAL MG/L		1	8.000000			8	8	51/03/02	51/03/02
00945 SULFATE SO4-TOT MG/L		1	19.00000			19	19	51/03/02	51/03/02
00950 FLUORIDE F,DISS MG/L		1	2.000000			2.00	2.00	51/03/02	51/03/02
00955 SILICA DISOLVED MG/L		1	11.00000			11.0	11.0	51/03/02	51/03/02
70301 DISS SOL SUM MG/L		1	387.0000			387	387	51/03/02	51/03/02
71851 NITRATE DISS-NO3 MG/L		1	.4000000			.4	.4	51/03/02	51/03/02
72008 TOT DPTH OF WELL FT		1	150.0000			150.0	150.0	51/03/02	51/03/02
72019 DEPTH-FT BL LAND SURFACE		1	130.0000			130.00	130.00	51/03/02	51/03/02
84000 GEOLOGIC AGE CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	51/03/02	51/03/02
84001 AQUIFER NAME CODE	TXT	1	TEXT	TEXT	TEXT	TEXT	TEXT	51/03/02	51/03/02

1STORET RETRIEVAL DATE 96/08/21 PGM=INVENT PAGE: 12

CHEMICAL ANALYSES REPORT

PARK: SALINAS

SYSTEM NUMBER: 7260NM904-30

SYSTEM NAME: QUARAI

CHEMICAL		RESULTS MG/L	COMPLY	DATE	RECORD
FLUORIDE (TEMP 1)		0.2200	Y	06/26/86	
NITRATE		0.6000	Y	06/26/86	
ARSENIC	<	0.0050	Y	07/16/86	
BARIUM	<	0.1000	Y	07/16/86	
CADMIUM	<	0.0010	Y	07/16/86	
CHROMIUM	<	0.0050	Y	07/16/86	
IRON	<	0.0500	Y	07/16/86	
LEAD	<	0.0100	Y	07/16/86	
MANGANESE	<	0.0500	Y	07/16/86	
MERCURY	<	0.0005	Y	07/16/86	
SELENIUM		0.0060	Y	07/16/86	
SILVER	<	0.0010	Y	07/16/86	
CALCIUM		90.0000	Y	07/21/86	
CARBONATE HARDNESS		0.0000	Y	07/21/86	
CHLORIDE		15.9000	Y	07/21/86	
COLOR	<	5.0000	Y	07/21/86	
FOAMING AGENTS	<	0.0500	Y	07/21/86	
LANGLIER INDEX		0.4000	Y	07/21/86	
MAGNESIUM		6.1000	Y	07/21/86	
NON-CARBONATE HARDNESS		211.8000	Y	07/21/86	
ODOR		0.0000	Y	07/21/86	
pH		7.5600	Y	07/21/86	
POTASSIUM		0.3900	Y	07/21/86	
SODIUM		18.4000	Y	07/21/86	
SPECIFIC CONDUCTANCE		391.0000	Y	07/21/86	
SULFATE		18.0000	Y	07/21/86	
TEMPERATURE		70.0000	Y	07/21/86	
TOTAL ALKALINITY		174.0000	Y	07/21/86	
TOTAL DISSOLVED SOLIDS		258.0000	Y	07/21/86	
TOTAL HARDNESS		250.0000	Y	07/21/86	
TURBIDITY		1.2200	Y	07/21/86	

NPS - PHS
WATER SUPPLY INFORMATION SYSTEM
CHEMICAL ANALYSES REPORT

PARK: SALINAS

SYSTEM NUMBER: 7260NM901-30

SYSTEM NAME: GRAN QUIVERA

CHEMICAL		RESULTS MGM	COMPLY	DATE
NITRATE		3.9400	Y	06/20/86
FLUORIDE (TEMP 1)		0.4900	Y	06/26/86
MAGNESIUM		50.1000	Y	06/26/86
CALCIUM		250.0000	Y	06/26/86
CARBONATE HARDNESS		0.0000	Y	06/26/86
CHLORIDE		36.4000	Y	06/26/86
COLOR	<	5.0000	Y	06/26/86
FOAMING AGENTS	<	0.0050	Y	06/26/86
LANGLIER INDEX		0.6000	Y	06/26/86
NON-CARBONATE HARDNESS		134.0000	Y	06/26/86
pH		7.5500	Y	06/26/86
POTASSIUM		2.3400	Y	06/26/86
SODIUM		27.6000	Y	06/26/86
SPECIFIC CONDUCTANCE		1543.0000	Y	06/26/86
SULFATE		696.1000	N	06/26/86
TEMPERATURE		70.0000	Y	06/26/86
TOTAL ALKALINITY		110.0000	Y	06/26/86
TOTAL DISSOLVED SOLIDS		1545.0000	N	06/26/86
TOTAL HARDNESS		830.0000	N	06/26/86
TURBIDITY		0.1200	Y	06/26/86
IRON		0.2700	Y	07/16/86
MANGANESE	<	0.0500	Y	07/16/86
COPPER		0.0090	Y	10/01/76
ZINC		0.6700	Y	10/01/76
ARSENIC	<	0.0500	Y	10/12/89
BARIUM	<	0.1000	Y	10/12/89
CADMIUM	<	0.0010	Y	10/12/89
CHROMIUM	<	0.0050	Y	10/12/89
LEAD	<	0.0050	Y	10/12/89
MERCURY	<	0.0005	Y	10/12/89
SELENIUM	<	0.0060	Y	10/12/89
SILVER	<	0.0010	Y	10/12/89